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Recommendation Domains for Pond Aquaculture

Country Case Study: Development and Status of Freshwater Aquaculture in Henan Province, China

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RECOMMENDATION DOMAINS FOR POND AQUACULTURE

Country Case Study: Development and Status of Freshwater Aquaculture in Henan Province, China

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WorldFish Center

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LIST OF ABBREVIATIONS

APR	average annual percentage growth
BCE	before the common era
CA	cultivated area
CAFS	Chinese Academy of Fishery Sciences
CAS	Chinese Academy of Sciences
CCAP	Center for Chinese Agricultural Policy
ESBF	Extension Station of Bureau of Fisheries
FAO	Food and Agriculture Organization of the United Nations
FFRC	Freshwater Fisheries Research Center
GDP	gross domestic product
GRP	gross regional product
GIS	geographic information system
ha	hectare
HH	household(s)
kg	kilogram
km	kilometre
na	not available
NBSC	National Bureau of Statistics of China
NFTEC	National Fisheries Technical Extension Centre
R&D	research and development
RD	recommendation domain
RMB	renminbi, the Chinese currency, also called yuan
s.e.	standard error
t	tonne (1,000 kg)
TVC	total variable cost
WTO	World Trade Organization

NOTES:

1. In this report, "$" refers to US dollars ($1 = RMB6.82 in July 2008).
2. References in Chinese statistics to "shellfish" include only molluscs, not shrimps or crabs, so we convert those references to "molluscs".

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FOREWORD

This monograph is a result of a 3-year project to produce a decision-support toolkit with supporting databases and case studies to help researchers, planners and extension agents working on freshwater pond aquaculture. The purpose of the work was to provide tools and information to help practitioners identify places and conditions where pond aquaculture can benefit the poor, both as producers and as consumers of fish. By undertaking the project in four countries (Cameroon and Malawi in Africa, and Bangladesh and China in Asia), each at a different stage of aquaculture development, project researchers were better able to test the toolkit for wide applicability and utility.

Applying such a toolkit requires a clear understanding of the existing state of pond aquaculture in each country, the circumstances underpinning its development, and the factors driving its adoption or discontinuation. To achieve this, country case studies were conducted by extensive literature review supplemented with analysis of primary and secondary data.

This monograph is the case study for China, with a particular focus on Henan Province, the project location. Written in three parts, it first describes the historical background, production levels and trends, economic and institutional environment, policy issues, and market situation in China in general. The main part of the study presents findings from two different surveys conducted in Henan Province. County-level information is used to analyze the current situation of aquaculture, providing a more disaggregated picture than what is generally available from national statistics. Data collected in a survey of fish farmers in two locations in Henan are then analyzed with regard to the prevailing aquaculture technology and production practices, economic performance of pond fish farming, and the key reasons for aquaculture adoption. In the final chapter, constraints and opportunities for the aquaculture sector in China in general are discussed.

I hope that this monograph will help development practitioners and researchers interested in aquaculture development in Henan Province and more broadly in China. The WorldFish Center and its research and national partners[1] are grateful to the Federal Ministry for Economic Cooperation and Development, Germany, for funding the project. We also thank all other partners, including fish farmer respondents, who have contributed to this effort.

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1 Research partners: University of Kassel and the University of Hohenheim, Germany; National partners: Institut de Recherche Agricole pour le Développement in Cameroon, Fisheries Department in Malawi, Department of Fisheries in Bangladesh and Chinese Academy of Fishery Sciences.

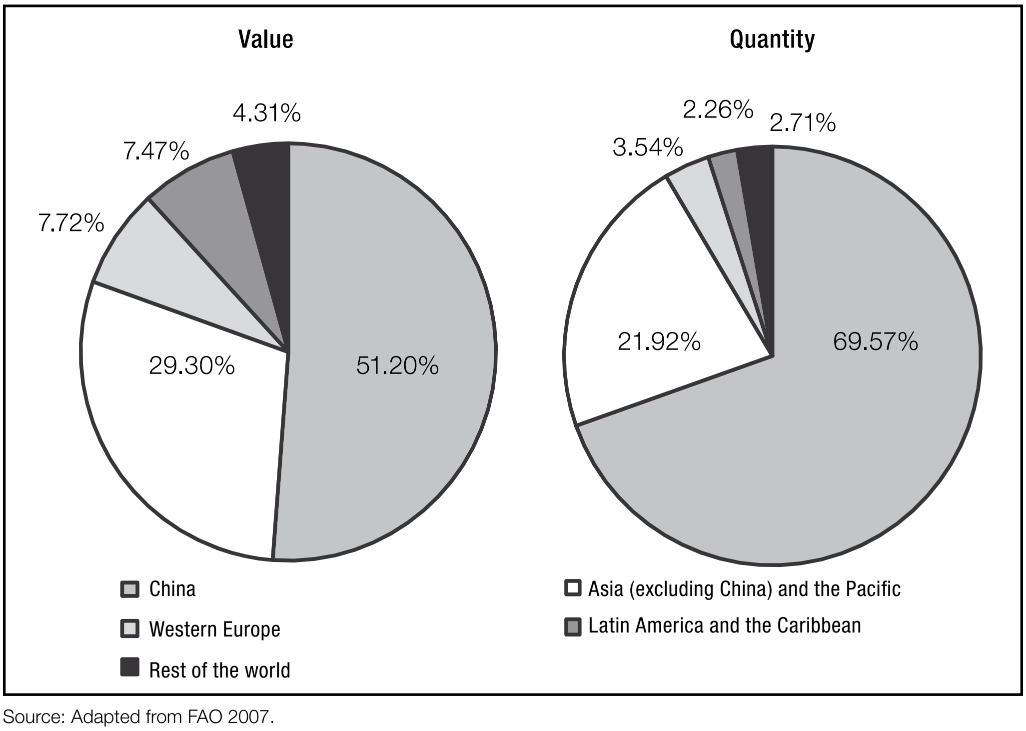
1. INTRODUCTION

Aquaculture has been the fastest growing food sector globally over the past several decades. Most of this growth has taken place in developing countries, and a large share of the increase in aquaculture production is from the dramatic growth of this sector in the People's Republic of China. The Chinese aquaculture sector is large, accounting in 2004 for 70% of global aquaculture production in terms of quantity and 51% in terms of value (Figure 1). Aquaculture in China is very diverse, spanning the full spectrum from extensive small-scale pond production of different finfish to the highly commercial and intensive cultivation of such luxury seafood items as sturgeon, soft-shelled turtles and crabs, in both marine and freshwater environments. It is thus very challenging to adequately capture this variety in a single review.

For this case study, we will start by giving a general overview of the national aquaculture sector in terms of development trends, current production levels and importance to the national economy. However, to avoid duplicating existing publications on aquaculture in China in general, we focus on describing the aquaculture sector in Henan Province, the study location for the Recommendation Domains (RD) project. Henan was selected because it presents a range of production systems from semi-intensive smallholder aquaculture in the south to intensive commercial aquaculture on the Yellow River floodplain. After a review of the national situation in chapter 2, we compile available secondary information of the aquaculture sector in Henan and subsequently present the results of two primary surveys conducted under the RD project.

We analyze first a countywide survey of fisheries bureau staff conducted to elicit key provincial indicators of aquaculture production and then a survey of households engaged in aquaculture production in two regions of Henan Province. This information fills a gap in more detailed information of aquaculture production in Henan, which we hope will be of use to practitioners and policymakers working in this area. The study closes with a general review of the major constraints and opportunities for aquaculture in China.

Figure 1: Global aquaculture production by regional grouping, 2004



Source: Adapted from FAO 2007.

2. OVERVIEW OF THE NATIONAL FISHERY SECTOR

2.1 ROLE OF AQUACULTURE AND CAPTURE FISHERIES IN THE NATIONAL ECONOMY

China is among the countries with the longest history of fishing and fish culture in the world. The country has a coastline 18,000 kilometres (km) long (almost double that if the coastlines of islands are included), fishable marine areas of around 1.5 million km^2, and 1.3 million hectares of shallow seawaters and mudflats. It has inland water bodies amounting to 17.5 million hectares, both tropical to temperate (Zhong and Power 1997). Capture fisheries in the sea, rivers, lakes and reservoirs have always been important economically, as well as for food and nutritional security. The first records of fish farming in China go back as far as the Zhou dynasty (1066-256 BCE), when carp fisheries were established. A monograph entitled *Treatise on Pisciculture*, written by Fan Li in 473 BCE, is the earliest known paper on aquaculture in the world (Li and Mathias 1994). Despite this early start, fish culture has developed rapidly only since 1950, when success in artificially breeding major carp species and the subsequent availability of hatchery-reared fry and fingerlings replaced the capture of fry from the wild and a range of improved culture technologies became available. In the past 50 years, aquaculture production has ballooned from only 20,000 metric tonnes (t) in 1949 to 34 million t in 2000, facilitated by the introduction of a free market economy policy in 1978 (FAO 1999).

Though the share of the primary sector in China's gross domestic product (GDP) has steadily fallen in recent decades from 28% in 1985 to 12% in 2006, agriculture still employed 43% of the nation's workforce in 2006, or 326 million people (NBSC 2007). Among agricultural labourers, some 3.29 million full-time labourers were engaged in aquaculture, mainly freshwater fish culture, in 1997, along with a huge number of part-time labourers who participated for the most part in constructing, renovating and managing ponds, as well as in harvesting and marketing fish (FAO 1999). The total number of people in China engaged in fishing and fish farming in 2004 was an impressive 13 million (FAO 2007). Women account for more than one third of the labour force in aquaculture (FAO 1997). In 2004, 28% of all the fishers in the world, and 40% of all fish farmers, were Chinese. The number of fish farmers in China grew by nearly threefold between 1990 and 2004, but the Chinese percentage of world fish farmers nevertheless fell slightly, indicating even faster fishery growth in other countries (Table 1).

According to the Food and Agriculture Organization of the United Nations (FAO), the average annual percentage growth rate of aquaculture between 2002 and 2004 was 5% in China, while the top performers, Myanmar and Vietnam, realized average annual percentage growth rates of 45% and 31%, respectively. However, Myanmar and Vietnam grew from much smaller bases, with Myanmar producing 0.4 million t in 2004 and Vietnam 1.2 million t (FAO 2007).

Despite the policy focus of the Chinese government to strengthen growth in rural areas and agriculture, a large difference in income persists between urban and rural

Table 1: Number of fishers and fish farmers globally and in China

	1990	1995	2000	2003	2004
World					
Fishers (million)	23.9	25.8	30.7	30.7	30.1
Fish farmers (million)	3.8	6.2	8.8	10.6	11.3
China					
Fishers (million)	7.4	8.8	9.2	8.8	8.5
Fishers (% of world)	30.9	34.1	30.0	28.7	28.2
Number fish farmers (million)	1.7	2.7	3.7	4.3	4.5
Fish farmers (% of world)	44.7	43.5	42.0	40.6	39.8

Source: FAO 2007.

households. In 2006, the average annual per capita income for urban residents was RMB11,760 ($1,724), or more than triple the RMB3,587 ($526) figure for rural residents. However, staffers employed in the fishery sector, both capture and culture, had incomes in 2006 averaging RMB12,415 ($1,820), or nearly half again the RMB8,610 ($1,262) figure for farm wage-earners (NBSC 2007).

The total productivity of the fisheries sector was estimated at 52.9 million t in 2006. The total value of the fisheries production is estimated to be RMB443,300 million ($65,000 million), contributing about 10% percent to the gross output value of the primary sector in 2006. The share of aquaculture in total fish production was 68% in 2006 (NBSC 2007). These statistics should, however, be read with caution. There is strong pressure to meet production targets, and people in charge of reporting try not to fall short. Meanwhile, figures may be underreported if the actual growth is higher than the target, to ensure the ability to report further growth in the future (Watson and Pauly 2001).

In addition to the fisheries sector's important role in generating employment and income and contributing to food security (see below), the trade in fish — a relatively high-value commodity — is a significant source of foreign currency earnings for producing countries. China is by far the largest exporter of fish and fish products worldwide, with exports worth $6.637 billion in 2004, or 9.3% of the global total (Table 2). Fishery products accounted for 29% of China's total agricultural exports, excluding forestry products, in 2004, but only 1.1% of the country's total merchandise exports (FAO 2007).

Table 2: Top ten exporters and importers of fish and fishery products

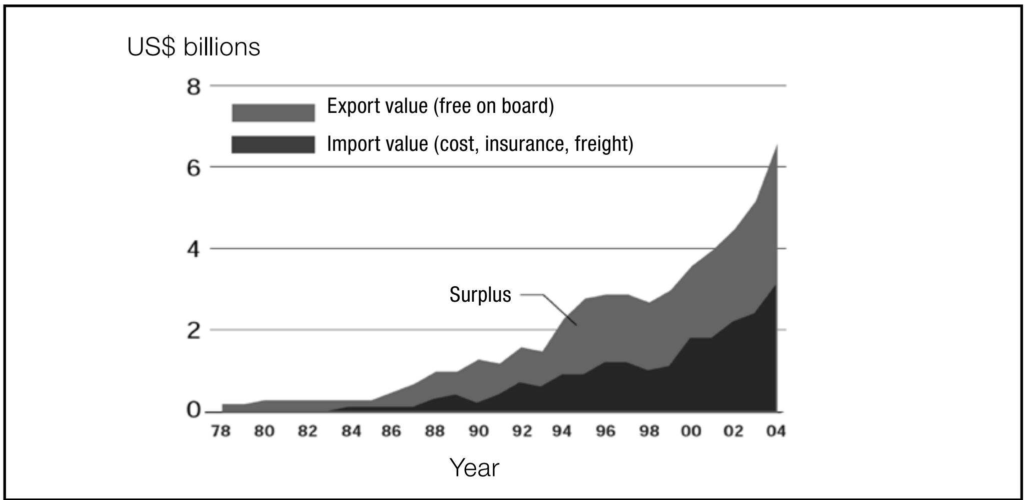
	1994 ($ million)	2004 ($ million)	Average annual growth (percentage)
Exporters			
China	2,320	6,637	11.1
Norway	2,718	4,132	4.3
Thailand	4,190	4,034	-0.4
USA	3,230	3,851	1.8
Denmark	2,359	3,566	4.2
Canada	2,182	3,487	4.8
Spain	1,021	2,565	9.6
Chile	1,304	2,484	6.7
Netherlands	1,346	2,452	5.5
Vietnam	484	2,403	17.4
Top 10 subtotal	**21,243**	**35,611**	**5.3**
Rest of world subtotal	**26,267**	**35,897**	**3.2**
World total	**47,511**	**71,508**	**4.2**
Importers			
Japan	16,140	14,560	-1.0
USA	7,043	11,967	5.4
Spain	2,639	5,222	7.1
France	2,797	4,176	4.1
Italy	2,257	3,904	5.6
China	856	3,126	13.8
United Kingdom	1,880	2,812	4.1
Germany	2,316	2,805	1.9
Denmark	1,415	2,286	4.9
Republic of Korea	718	2,233	12.0
Top 10 subtotal	**38,063**	**53,090**	**3.4**
Rest of world subtotal	**13,104**	**22,202**	**5.4**
World total	**51,167**	**75,293**	**3.9**

Source: FAO 2007.

China's fish and fish product exports have increased significantly, with an average annual percentage growth of 11% for the period of 1994 to 2004. The major driver behind this rapid increase in exports of aquatic products, apart from the growing production of the fisheries sector, is the expansion of the fish-processing industry. Processing is done not only of domestically sourced fish but also of imported raw material, which is then re-exported after this value-adding step (FAO 2007). According to FAO, China's imports of fish and fish products increased by 14% per annum from 1994 to 2004 (Table 2 and Figure 2), partly as a consequence of the reduced import duties after the country joined the World Trade Organization (WTO) in late 2001. The most commonly imported seafood products are fishmeal used as feed in the rapidly expanding aquaculture subsector, pollock, medium- and high-grade salmon and trout, crab, and lobster (Yang 2005).

The major exported aquaculture products in 2003 (Table 3) were frozen shrimp, either processed or not, which accounted for 36% of total value and 21% of the volume of all aquaculture exports; live or iced fish, accounting for 17% of the value and 28% of volume; baked eel, accounting for 19% of value and over 8% of volume; and crab, accounting for 11% of value and 8% of volume.

Figure 2: China's imports and exports of fish and fish products



Source: Adapted from FAO 2007.

Table 3: China's exports of major aquaculture products, 2003

Products	Value		Volume	
	($ million)	(% of total)	('000 t)	(% of total)
Shrimp, frozen with head on, headed and peeled, or breaded	880	35.9	132.6	20.6
Eel, baked	470	19.2	54.0	8.4
Tilapia, gutted and frozen or filleted	100	4.1	60.0	9.3
Yellow croaker, live or frozen whole	110	4.5	49.0	7.6
Crab, live, frozen or cut	270	11.0	49.0	7.6
Seaweed or derived products	100	4.1	50.0	7.8
Fish, live or iced	410	16.7	180.0	28.0
Mollusc	110	4.5	69.0	10.7
Total	**2,450**	**100**	**643.6**	**100**

t = tonne.
Source: Yang 2005.

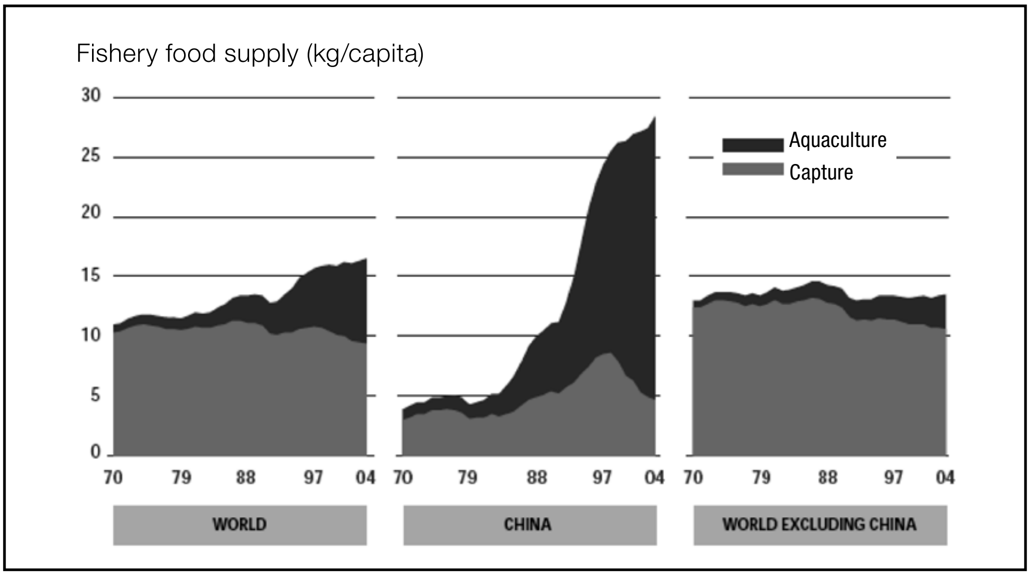
In addition to providing employment and income and generating export earnings, China's fishery sector, and especially aquaculture, plays an important role in national food security. Aquatic products provide a large share of animal protein intake. According to the National Bureau of Statistics, total fish production has exceeded pork production since 1997, making fish the most commonly available source of animal protein (Annex 8). In 2004, fish accounted for 29% of all animal protein produced in China, with the annual per capita supply of fish approaching 30 kilograms (kg) (Figure 3). Fishery production per capita is much greater in China than the global average, and the contribution of the aquaculture subsector is enormous. However, as described above, large quantities of fish are exported, so the actual consumption of fish in China is considerably lower than per capita production would suggest.

Even taking into account the significant share of aquatic products that are exported, fish is still a major part of the Chinese diet. Annual per capita consumption of aquatic products in rural households has increased from 2.13 kg in 1990 to 5.01 kg in 2006. In 2006, annual per capita consumption of aquatic products in urban households was 18.4 kg in the eastern region, 10.3 kg in the centre, 7.6 kg in the west and 12.5 kg in the northeast (NBSC 2007).

2.2 AQUACULTURE PRODUCTION TRENDS

Aquaculture has been practised in China for millennia, and fish has always played an important role in Chinese culture. However, the rapid development of aquaculture and fisheries did not start until the founding of the People's Republic of China at the end of the 1940s. Since the 1980s, the sector has grown dramatically, becoming one of the fastest growing primary sector industries in China. In 2005, aquaculture production was 43.27 million t, a 23-fold increase over the 1.88 million t produced 3 decades earlier in 1975 (FAO FishStat Plus 2007). Despite the declining role of agriculture in China's national economy, the fishery sector keeps pace with overall economic growth, experiencing significant structural changes. The proportion of aquaculture output in total national fishery output increased from 35% in 1975 to 71% in 2005 (Table 4). The share of capture fishery production in total national fish production consequently declined over this period (Li and Huang 2002).

Figure 3: Contribution of aquaculture and capture fisheries to food fish supply, world vs China, 2003



kg = kilogram.
Source: FAO 2007.

Table 4: Production trends in the Chinese fishery sector, 1975-2005

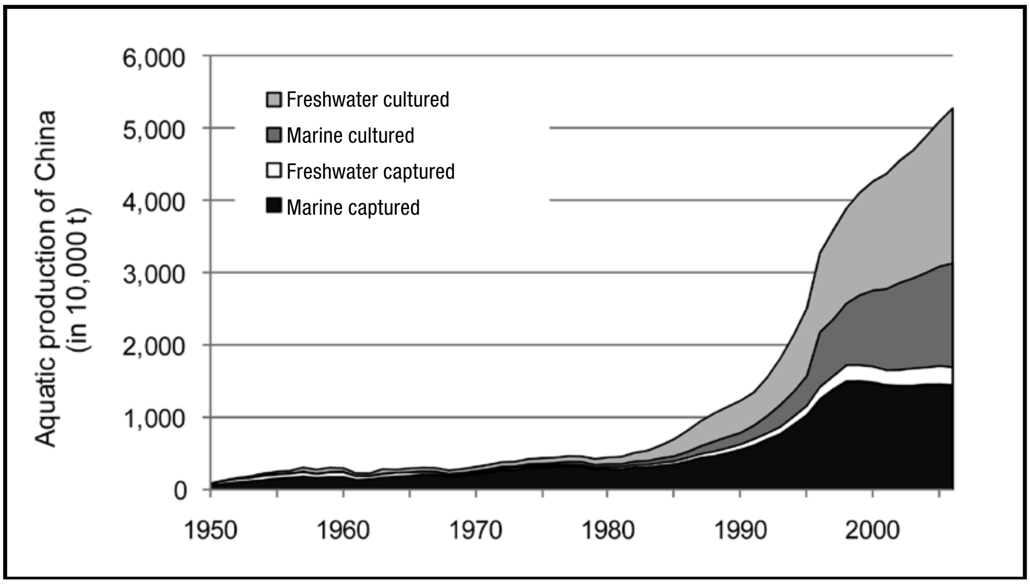
	1975	1980	2000	2005
Capture fisheries ('000 t)	3,497	3,147	17,192	17,362
Aquaculture ('000 t)	1,876	2,660	34,210	43,269
Aquaculture % of total production	34.9	45.8	66.5	71.4

t = tonne.
Source: FAO Fishstat Plus 2007.

Marine capture fisheries constituted the most important fishery subsector in China until the end of the last century but have since been stagnant. Starting in the 1990s, the emphasis shifted to aquaculture. The most impressive growth has been realized in the area of freshwater aquaculture (Figure 4 and Annex 3). Remarkably, China is the only country among the world's major fish producers whose aquaculture harvest exceeds that of capture fisheries (Wang 2001, FAO 2005). Aquaculture production in China has grown at an average annual growth rate of 11% over the past 3 decades, far outpacing the global growth rate (Figure 5).

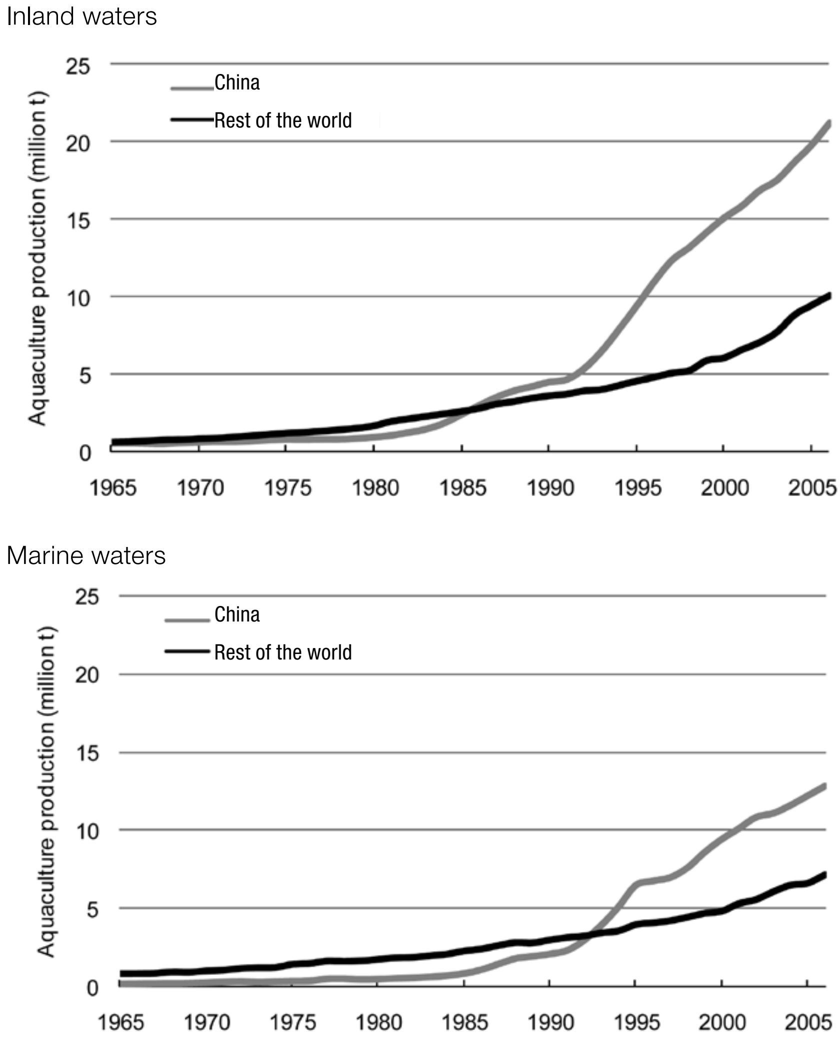
The dramatic increase, particularly in cultured fish production, results from both area expansion and rising productivity. Technological change is the primary engine for the rapid growth that has occurred since the 1980s (CCAP and FFRC 2004, Li and Huang 2002). Li (2003) gives an overview of the progress in artificial reproduction and the nursing of cultured freshwater species. By 2003, complete artificial propagation (i.e., with the whole lifecycle controlled artificially) had been successfully accomplished for 45 of the 59 species of cultured freshwater finfish. For only six fish species was there no success in artificial propagation, and for the remaining eight the brooders were still collected from the wild. Artificial propagation was also achieved for the major crab, prawn, mollusc and turtle species (Annex 4). This technological progress greatly improved the availability of fry and fingerlings. In addition to greater fingerling quantity and higher quality, there were other improvements in the production system, as aquafeeds became available and were widely used and, with the general availability of electricity, powered aerators were installed in many fishponds. This allowed the large increase in yields realized in all aquaculture production environments (Annex 5).

Figure 4: Output of aquatic products in China by environment, 1950-2006



t = tonne.
Source: NBSC 2007.

Figure 5: Trends in aquaculture production in inland and marine waters



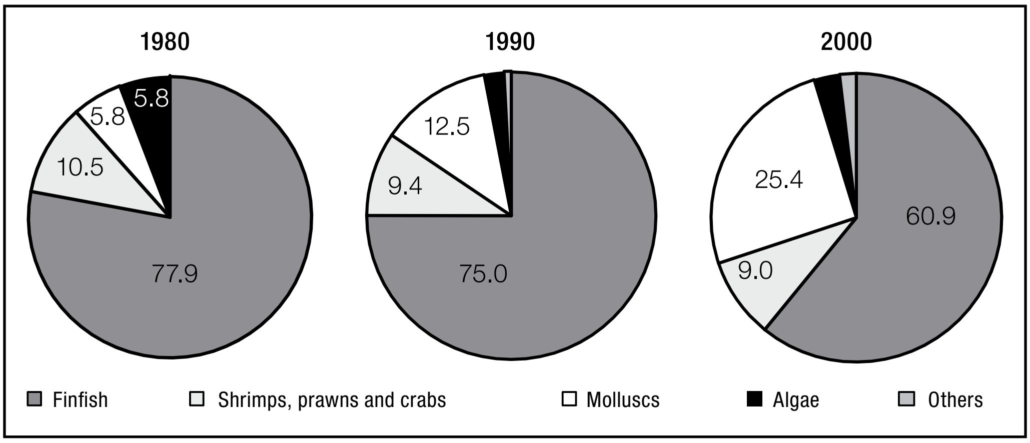
Note: Data exclude miscellaneous animal products.
Source: FAO Fisheries and Aquaculture Information and Statistics Service, available at www.fao.org/fishery/statistics/global-aquaculture-production/query/en (accessed on 21/11/2008).

According to Zhong and Power (1997), the increase in freshwater capture fisheries (Annex 3) can be attributed to (1) the stocking of natural water bodies, mainly with carps; (2) more intensive exploitation of previously lightly fished lakes and reservoirs in remote areas; and (3) increased fishing effort in general. However, Chinese capture fisheries have not significantly increased production since the late 1990s (Figure 4).

The lion's share of the aquatic products produced in China is various species of finned fish. However, other products, especially high-value species such as shrimp and molluscs, are catching up, with the share of finned fish in total aquatic production falling from 78% in 1980 to 61% in 2000 (Figure 6).

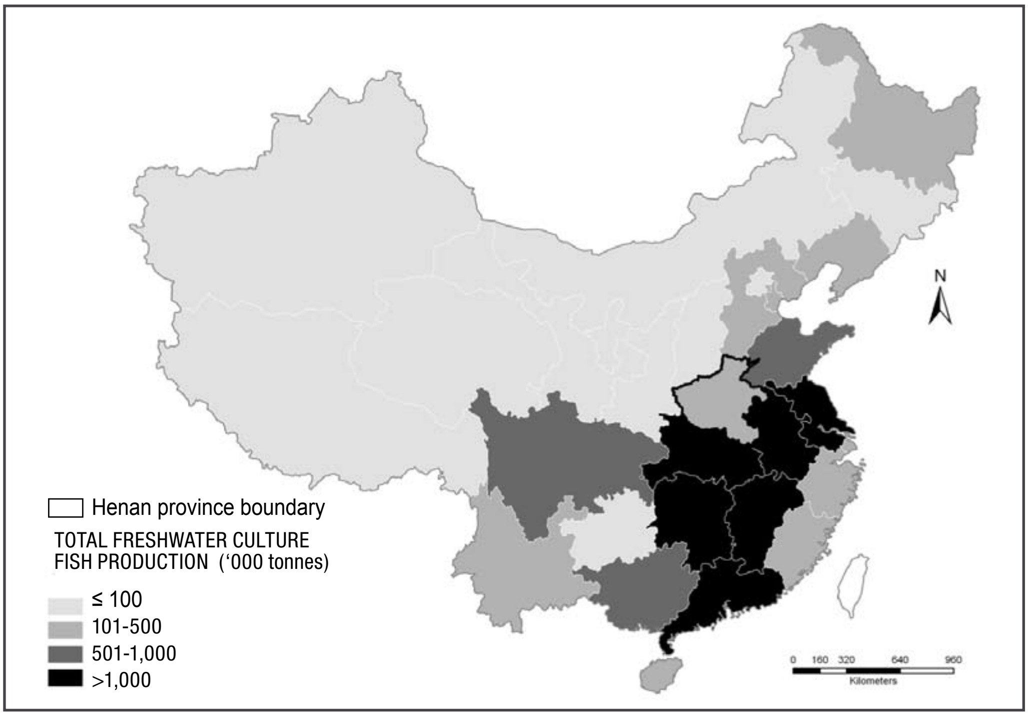
The major freshwater fish-producing provinces, each accounting for more than 1.2 million t of freshwater fish production, are Guangdong, Hunan, Hubei, Anhui and Jiangsu (Figures 7 and 11, the latter showing province names). The same provinces are the leaders with regard to freshwater fish production in ponds, each with more than 0.72 million t. But when considering the relative importance of freshwater fish ponds — the share of pond production in total freshwater fish production (Figure 8)

Figure 6: Share of different aquatic products in total output in China (%)



Source: NBSC 2007.

Figure 7: Total freshwater culture fish production in China by province



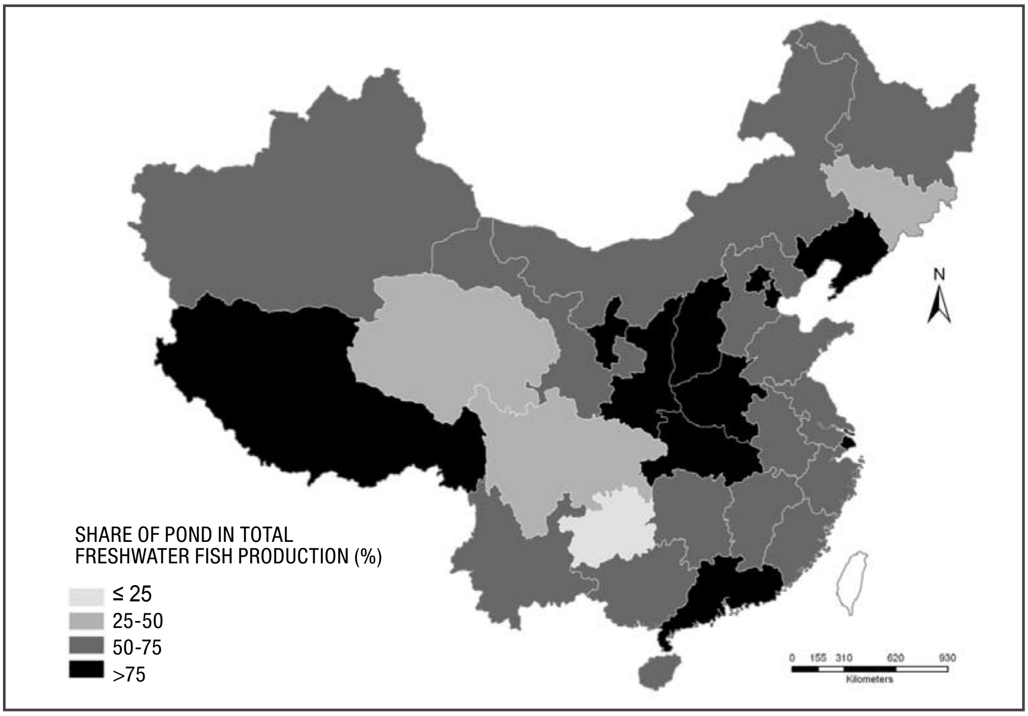
Source: NBSC 2004.

— some other provinces, including Henan, the study area for the RD project (outlined in bold in Figures 7 and 11), reach more than 75% (Figure 8).

2.3 ECOSYSTEMS FOR AQUACULTURE AND OVERVIEW OF FARMING SYSTEMS

A number of different aquatic ecosystems contribute to aquaculture production in China. With respect to location and water salinity, these ecosystems can be grouped into two broad categories: (1) inland and (2) brackish plus marine. Although rich in water resources in absolute terms, China ranks only 85th in the world in terms of inland water resource availability per capita (CCAP and FFRC 2004), indicating that freshwater is a limiting factor for pond aquaculture nationwide. In 2001, the aquatic ecosystems that made the largest contribution to

Figure 8: Share of ponds in total freshwater fish production in China by province



Source: NBSC 2004.

aquaculture production were inland ponds, with 41% of national production. The second largest contributor was mudflats, accounting for 20%, followed by shallow sea ecosystems with 18%. Lakes, rivers, reservoirs and other inland open-water ecosystems accounted for 11%.

INLAND ECOSYSTEMS

China has a total inland water area of 18,199,412 hectares (ha), including 2,286,079 ha of fishponds in 2001 and accounting for 1.9% of Chinese territory (CCAP and FFRC 2004, Miao et al. undated). Of the various inland aquaculture systems, pond culture is the most popular and important fish-farming system in China, accounting for 72% of total inland aquaculture output in 2001 (Table 5). In that year, ponds occupied only 33% of the total inland aquaculture area. This production environment has higher yield mainly because of the high intensity of production, with feeding, fertilizing and aeration of ponds (Annex 5). The majority of the ponds are concentrated in the basins of the Yangtze and Pearl rivers, covering the seven provinces of Guangdong, Jiangsu, Hubei, Hunan, Anhui, Jiangxi and Shanghai, which together account for 68% of the country's inland aquaculture output (FAO 2005). Freshwater aquaculture is also found in open water bodies such as reservoirs, lakes and rivers. The first reservoir was constructed about a thousand years ago in Zhejiang Province for irrigation. Only 20 reservoirs existed a millennium later, when the People's Republic of China was founded. Since then, many reservoirs have been built. Today, there are nearly 85,000 reservoirs with an estimated total water surface area of 2 million ha and a storage capacity of 457 billion cubic metres.

Other important inland water resources are lakes, of which there are over 24,000 of various sizes. The majority of lakes are smaller than 50 km² and less than 10 m deep. The water surface area of all lakes accounts for 42.2% of the total inland water area. However, many of these open water bodies have suffered from pollution over the past four decades and thus lost a lot of fishery potential (Miao et al. undated).

Table 5: Area and aquatic production of freshwater environments, 2001

Types	Cultured area ('000 ha)	% of total area[a]	Production ('000 t)	% of total production
Pond	2,220	33.4	10,876	71.7
Lake	895	13.5	933	6.2
Reservoir	1,621	24.4	1,494	9.8
River	378	5.6	664	4.4
Rice field	1,532	23.1	746	4.9
Other	na	na	456	3.0
China total	**6,646** [a]		**15,169**	

ha = hectare, na = not available, t = tonne.
[a] *The China Statistical Yearbook 2002* reports a total area "utilized" of 5,278,000 ha, which is lower than the sum of the cultured area for the individual environments. We have thus added up the figures for the different cultured areas (reported as China total cultured area) and based the percentage shares on this figure.
Source: NBSC 2002.

In addition to the areas reported as "cultured" in Table 5 under the various inland aquatic ecosystems, large areas that could be used for aquaculture exist, especially rice fields, with an estimated total area of 28,812,420 ha. A number of documents also point to "swamp" waste areas, which are estimated to cover 11 million ha (CCAP and FFRC 2004). However, the most extensive wetlands are found in Tibet and Qinghai, which are most likely unsuited for aquaculture because of their very long, cold winters and their remoteness from markets in major urban centres. An additional concern with converting swamps or wetlands into aquaculture production areas is the loss of the ecological and recreational services of such "wastelands".

BRACKISH AND MARINE ECOSYSTEMS

With its long coastline, China has abundant marine and brackish water resources.The total marine area within the exclusive economic zone of China is 472,700 km^2. Statistically, marine and brackish ecosystems are not clearly separated but classified into three general types: mudflats, shallow sea (up to 10 m in depth) and deep sea (over 10 m). Table 6 gives an overview of the extent of marine and brackish water environments in China. Various marine fish species and molluscs have been developed for marine and brackish water farming during the past 2 decades. Cultured area was 117,000 ha, with production of 415,900 t, in 1979 and climbed to 1,530,000 ha in 2003, with production of 12,530,000 t (FAO 2005).

FARMING SYSTEMS

As stated above, the aquaculture subsector in China is extremely diverse, spanning the full spectrum from extensive, small-scale production to very high-intensity commercial firms. In addition to the modification of traditional aquaculture techniques, numerous new technologies have been developed to improve the production and quality of aquaculture products. Many diverse aquaculture technologies are thus currently employed in China. They fall into three categories: (1) freshwater aquaculture in inland ecosystems, (2) marine and brackish water culture, and (3) hatchery technologies. The following paragraphs provide a brief overview of the most common farming system in each of these categories.

Table 6: Marine and brackish water environments in China (1,000 ha)

Environments	Bohai Sea	Yellow Sea	East China Sea	South China Sea	Total
Mudflat	507	549	493	369	1,918
Shallow sea	1,662	2,019	2,119	1,592	7,392
Deep sea	5,571	35,432	74,387	348,093	463,483
Total	**7,700**	**38,000**	**77,000**	**350,000**	**472,700**

ha = hectare.
Sources: Compiled from Miao et al. undated, CCAP and FFRC 2004.

Inland aquaculture systems comprise mainly ponds but also reservoirs, rivers and lakes with either stock enhancement or cage or pen culture. Traditionally, freshwater aquaculture in China is polyculture, which makes the best use of available resources in terms of the habits and food requirements of the farmed aquatic species. The most commonly used traditional fish are various carp species (Table 7). Expanding on indigenous species, a large number of exotic aquatic species have been introduced to China. Ma et al. (2003) list around 70 exotic species and 100 native species that have been intentionally introduced or stocked in China's inland waters. Among them, the Nile tilapia, produced in 23 out of 30 provinces, is the most commonly used species for fish culture and among the major export species (Zhong and Power 1997). Depending on the technology and intensity, the aquaculture systems can be monocultures, and in many cases aerators and feeding machines are used. Technologies vary from earthen ponds to cages and pen culture in open water bodies, and on to indoor tanks with running water systems. Fish in rice paddies is an integrated system of aquaculture, and earthen ponds can be integrated with other agricultural pursuits such as livestock or vegetables. Of the various types of aquatic animals, finfish are the most popular group. Depending on farming practices, intensity and the socioeconomic environment, the amount of inputs used in different aquaculture systems varies greatly. Typical inputs are formulated feed, seed, chemical and mineral fertilizer, manpower, and electrical power or fuel to run aerators or feeding machines.

Brackish water aquaculture technologies are primarily pond polyculture or monoculture systems. The intensity varies from extensive to intensive. Within marine aquaculture systems, various technologies are applied. Monoculture systems use cages, rafts with hanging nets, or indoor running water systems. Polyculture marine technologies include sea bottom and mudflat culture methods. The major species produced in brackish water and marine environments are molluscs such as oysters (31.0% of brackish water aquaculture production), clams (23.2%) and scallops (8.5%) (CCAP and FFRC 2004), as well as seaweed. As with freshwater aquaculture systems, the inputs used vary with intensity and practice.

In general, freshwater, marine and brackish water cultivation have all shifted toward the production of high-value species such as mitten carp, prawn, eel, frog, crawfish, grouper, pearl oyster, abalone and sturgeon. In 2003, high-value species accounted for about 30% of total aquaculture production by value, compared with only 1% in 1979. Table 7 shows the dominant aquaculture species in 2003.

China also has a growing sector producing ornamental fish, mainly goldfish, for aquariums and recreational ponds. The value of China's exports of ornamental fish was estimated at $19 million in 2000, accounting for 10% of global exports and 15% of the exports of Asian suppliers (Ling and Lim 2005).

Hatchery technologies play an important role in aquaculture development and resource enhancement by making production independent of wild-caught fry. This not only takes pressure off natural ecosystems but also provides much more flexibility in terms of the location and timing of aquaculture

Table 7: Major species in Chinese freshwater and marine aquaculture, 2003

Freshwater aquaculture		Marine aquaculture	
Major species	**Share by value (%)**	**Major species**	**Share by value (%)**
Silver carp and bighead carp	30.1	Finfish	4.1
Grass carp	20.2	Crustacean	5.3
Common carp	13.2	Mollusc	78.6
Crucian carp	10.0	Seaweed	11.0
Tilapia	4.2	Other	1.0
Other	22.3		

Source: Yang 2005.

production, as well as facilitating quality control and strain enhancement. Hatcheries used to be operated by the government, but this has changed dramatically over recent decades with economic liberalization. Today, there are two general types of hatcheries in China. The first operates on a large scale with small margins, culturing common species such as carps. The second operates on a smaller scale with higher margins, culturing high-value species such as marine fish. A successful hatchery operation can be highly profitable. As adopting hatchery technologies requires high investments, skills and technological knowledge, small-scale farmers hardly benefit directly from these technologies. Hatchery technologies are an important support to the aquaculture sector, as they provide the most essential input: fish seed (Miao et al. undated).

2.4 POLICIES AND REGULATIONS FOR CAPTURE FISHERIES AND AQUACULTURE

The major government institution for fishery administration in China is the Bureau of Fisheries, under the Ministry of Agriculture. Major functions of the Bureau of Fisheries are to (1) formulate plans, strategies, policies and programmes for fisheries development; (2) guide the economic reform of fisheries; (3) implement, monitor and enforce the fishery laws, regulations, and international and bilateral fisheries agreements; (4) strengthen fishery management to properly utilize fishery and aquatic resources and protect the fishery environment; (5) support fishery education and scientific research; (6) supervise and administer fishing vessel safety and superintend fishing ports; and (7) administer the building of fishing boats and the manufacture of fishery machinery and gear (FAO 1997). Under the Bureau of Fisheries, there are provincial and municipal fishery authorities for major fishery cities and counties, which are under the supervision of the local government and have similar functions as the Bureau of Fisheries in their respective areas.

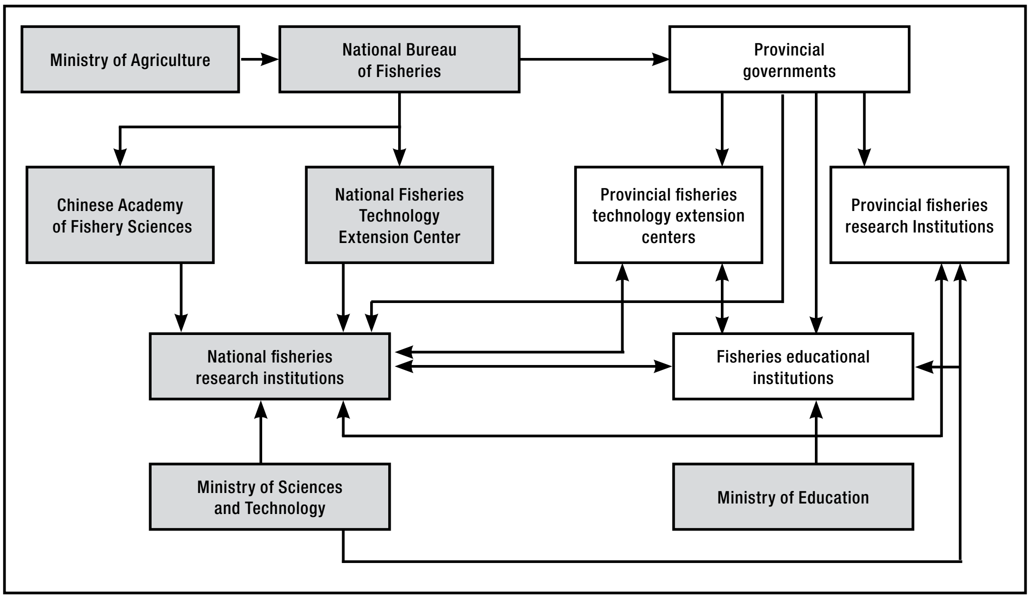
The Bureau of Fisheries has 10 divisions since being reformed in 1998. Among them is a division of aquaculture and a division of resource and environment protection (see Yang [2005] for the organizational structure of the Bureau of Fisheries). Other related institutions include the National Fisheries Technology Extension Center, with branches for each province, prefecture and autonomous region, and fisheries research and education institutions, which are major players in the fisheries sector (Figure 9). There are separate institutions for legal technical inspection of fishing vessels (Bureau of Fishing Vessel Inspection), fishery law enforcement in large inland water bodies and at major ports, and fishery environmental monitoring stations (FAO 2008). Other government institutions related to fisheries include the State Oceanic Administration, National Environmental Protection Agency and Ministry of Water Resources (FAO 1997).

The strategies followed by the Chinese government are very different for the capture fishery and aquaculture subsectors, though the overall goal of all agriculture and aquaculture policy is food self-sufficiency. The management objective for coastal marine capture fisheries became zero growth in 1999 and has been minus growth since 2001 (FAO 2008), while the growth of aquaculture has been highly encouraged and promoted. The major reason for halting the intensification of capture fisheries is declining wild fish stocks, indicated by the growing catch of small and immature fish. To achieve a reduction of coastal capture fisheries, the government has since 2002 reduced the number of fishing vessels and moved fishermen out of marine capture fisheries. Similarly, closed seasons, during which fishing is banned in major inland fishing areas such as the Yangtze River and a number of reservoirs and lakes, were introduced in 2003 (FAO 2008).

The major laws and regulations with implications for fisheries are listed in Box 1. As our focus in this study is on the freshwater aquaculture, we will concentrate on policies and regulations of relevance for this field rather than try to cover capture fisheries as well.

The development of aquaculture in China can be divided into three phases based on the prevailing policy environment: pre-1949,

Figure 9: Administrative and technical linkages of fishery-related government institutions in China



Note: Boxes with grey background are national institutions.
Source: Adapted from Hishamunda and Subasinghe 2003.

Box 1: Major laws and regulations for fisheries in China

Fishery Law of the People's Republic of China. As amended in October 2000, it entered into force on 1 December 2000. Reflecting the changing international regime of the sea and changing trends in fisheries resources, the new law adjusts management scope and stipulates control systems to limit catches. In aquaculture, the law stipulates that units or individuals who wish to use designated areas must apply for an aquaculture permit through the competent fishery administration at or above the county level and that the aquaculture permit will be granted by the people's government at the same level to allow use of the area for aquaculture.

Regulation for Living Resources Conservation in Bohai Bay. Entered into force on 1 May 2004, the regulation clearly stipulates requirements for capture fisheries, aquaculture, stock enhancement and the protection of the fishery environment in Bohai Bay.

Regulation of Fishing Vessel Inspection, People's Republic of China. Entered into force on 1 August 2003, the regulation stipulates the inspection of fishing vessels.

Notification of Implementing Closed Season for Fishing in the Yangtze River. The notification establishes closed seasons for fishing in the Yangtze River from 2003.

Regulation of Capture Fisheries Permit Management. Entered into force on 23 August 2002.

Management Method of Fisheries Fry and Fingerling. Entered into force on 8 December 2001 and replacing an earlier act of the same name issued in June, the new method stipulates wild fry and fingerling protection and methods of variety selection, production, and the management of imports and exports.

Source: FAO 2008.

1949-1978, and post-1978 (Hishamunda and Subasinghe 2003). Before 1949, aquaculture was a household enterprise driven by home consumption needs and economic motives. The 1949-1978 period was characterized by the government's primary goal of achieving food self-sufficiency and meeting the animal protein needs of the growing population. At the same time, funds were invested in marine aquaculture research to produce seaweed and kelp for export to earn foreign exchange (Hishamunda and Subasinghe 2003). During this period, aquaculture enterprises belonged to either the state or collectives.

In 1978, policy changes took place that stressed the household contract responsibility system with remuneration linked to output, thus moving away from collectives (FAO 1999). This liberalization of the rights of land use and farm management was one major reform that facilitated the development of aquaculture by leaving production decisions to farmers. Farmers were actively encouraged to convert low-lying, saline-alkali land or other "wasteland" unsuitable for agriculture to aquaculture and benefitted from preferential policies and privileged fiscal and investment measures (Wang 2001). With subsequent changes in economic policies in the 1980s, China created an enabling environment for the development of market-oriented aquaculture (FAO 2005). The liberalization of government price controls, letting fish prices be determined by prevailing market conditions, was a major incentive for aquaculture producers (Wang 2001). This new policy environment — together with some technological breakthroughs, especially artificial propagation — facilitated the fast growth of aquaculture, which took off earlier and proceeded faster than other areas of the agricultural economy. Growth was indeed so fast that the fishery production target set in the ninth 5-year agricultural plan (1996-2000) was already met by 1997, allowing the fish production target to be raised from 28.5 million t to 35 million t, with aquaculture accounting for more than 60% (FAO 1999). The long-term tentative target for national fishery production to reach 51 million t, worth RMB350 billion, by 2010 (Wang 2001) was reached or exceeded by 2006.

The declared development goals of the Chinese government for the development of the fisheries sector, as listed by Yang (2005), are to

- adhere to the guiding principle of "giving priority to aquaculture and develop capture fisheries and processing simultaneously" and to "take measures and lay emphasis in light of local conditions";
- further improve the structure of the fishery industry;
- speed the development of aquaculture;
- devote major efforts to spreading healthy cultivation methods, with emphasis on developing efficient and ecologically sound aquaculture;
- energetically develop where suitable the technology and capital needed for raceway fish farming;
- develop leisure fisheries;
- increase the share of aquaculture to 67% of total fish production by 2005;
- strictly control offshore fishing effort and avoid increasing the marine capture catch;
- develop an aquatic processing industry and enhance aquatic processing and comprehensive utilization levels;
- increase the share of processed aquatic products to 40% of total fish production by 2005;
- enhance the construction of fishery infrastructure, establish service systems, and improve aquatic product quality and the safety inspection system;
- increase the use of high-quality seed in aquaculture to 70% by 2005;
- ensure that major aquaculture diseases are effectively prevented and treated; and
- strengthen the fisheries legal system and establish and improve new fishery management regulations.

The development objective over the next 5-10 years is for China's fisheries to encompass a healthy capture fishery, advanced aquaculture, newly developed leisure fishing and a sound fishery ecological environment (Yang 2005). The government strategy recognizes that this will require increased effort to protect fishery resources and the environment, the sustainable development of aquaculture, improved international communication and cooperation, increased participation in international markets, the establishment of fishery information systems for marketing, better enforcement of laws and regulations, enhanced fishery infrastructure and support systems, and continued focus on strategic research (Yang 2005). The strategy to achieve the goals set for aquaculture will be to sharpen the focus on producing species with higher value, improving pond management, intensifying production, establishing standards for fish seed and feed, and expanding the area of rice-fish culture. The government has identified six major areas of concern with regard to future aquaculture development that will receive prime support: (1) species diversification including high-value products, (2) fishery science and standardization, (3) fishery technology extension, (4) disease control, (5) marketing, and (6) fishery management and environmental protection (Wang 2001).

China's entry into WTO in 2001 required that the average tariff on aquatic products be cut to 10-12% by 2004. As the average tariff on aquatic products was only 14.3% before joining WTO, no major shock was expected (Li and Huang 2005). However, for certain products such as live prawns and fresh or chilled fish fillets, tariffs were significantly higher at 24%, and cutting them will result in a major price shock for the domestic market if large amounts of cheaper imported products enter the country. That said, prices for most aquatic products in China were lower than the world market prices, so WTO accession is likely to further increase China's fish exports (ibid). At the same time, domestic prices are likely to increase as a consequence of opening up to the world market.

Mainly in response to the food quality and safety concerns of countries importing aquatic products from China, and to rising domestic concerns about food safety, the Ministry of Agriculture issued directives in October 2004 to all relevant authorities throughout the country to stop using banned chemicals and drugs in the production of aquaculture or related feed products (Agri-Food Trade Service 2005).

2.5 CAPTURE FISHERY AND AQUACULTURE RESEARCH, EDUCATION AND EXTENSION

As indicated above, research innovations, especially in hatchery technology and the artificial production of fish seed, have been crucial factors in the fast growth of aquaculture in China in recent decades. The government invested in a comprehensive research system mainly in the form of national fishery research institutions (Hishamunda and Subasinghe 2003). Related education and extension efforts aiming to disseminate the latest technologies and knowledge have received similarly strong support from the government. Only relatively recently has private sector aquaculture extension emerged, mainly in the form of information and training provided by seed and feed manufacturers.

As part of larger attempts to reform public institutions, according to CCAP and FFRC (2004), the "Chinese government is currently trying to reduce the number of national aquaculture and fisheries research institutions and the number of staff directly engaged in research and development activities. Meanwhile, the per capita investment for the [remaining] institutions … will be significantly increased. The major purpose is to improve the efficiency of aquaculture and fisheries R&D in China."

At the same time, greater emphasis is placed on the more efficient and timely dissemination of research findings to narrow the gap between the level of knowledge and technology available within research institutions and the actual practices used in production (CCAP and FFRC 2004).

The following paragraphs discuss the institutional framework, major actors and their responsibilities, as well as government priorities in the areas of fisheries education, research and extension.

FISHERIES EDUCATION

A number of Chinese institutions provide mid-level and higher education in the area of fisheries. All human resource development for the sector currently takes place under the government education programme, with no participation of the private sector (Hishamunda and Subasinghe 2003). Students who have completed 9 years of elementary and junior high school can enter one of 16 fishery technical schools to obtain mid-level training (Annex 7). After completing senior high school (an additional 3 years) students can enter university or college for a 3-4 year programme in fisheries. All universities in China are administered under the Ministry of Education since the reform of higher education in 1976 (Hishamunda and Subasinghe 2003). There are currently eight independent fishery universities and colleges, and 10 Chinese agricultural universities have fishery departments that provide specialized training in this field (Li and Mathias 1994). These institutions offer courses toward bachelors, masters and doctorate degrees in aquaculture or closely related areas (Hishamunda and Subasinghe 2003).

FISHERIES RESEARCH

The research system consists mainly of national fishery research institutions supported by the Chinese government and directly administered by the Chinese Academy of Fishery Science (CAFS). CAFS, directly under the Ministry of Agriculture, is a leading research institution in China involved in almost all research fields for both marine and freshwater environments, including resource surveying and enhancement, aquaculture, fishing, product processing, machinery, environmental protection, engineering, economics, and information (FAO 1997). Since its foundation in 1978, CAFS has performed over 1,000 studies, of which more than 250 received awards from the state or its ministries. Headquartered in Beijing, CAFS has 15 related institutions across China focused on various disciplines (Annex 6). The academy currently employs 1,590 scientists, 51 research fellows and 340 associate researchers.

Additional research institutions are supported by provincial and municipal governments or universities. In total, China had 210 fishery research institutes in 1999 employing 7,000 professionals. The national research institutions pursue both basic and applied research with a focus on developing technologies that address the needs of national aquaculture development. Locally supported research institutions focus more on solving technical problems that affect local aquaculture development (Hishamunda and Subasinghe 2003).

To fulfil the ambitious development plan, priorities identified for government-funded research institutions are research on

- bioengineering technology, with the emphasis on improved new culture species or strains;
- the development of sustainable fisheries enhancement and aquaculture to assure positive and rational development;
- disease control and production technology for aquaculture, with particular reference to molecular biology tools;
- development options to transform traditional aquaculture systems, develop new culture technology systems such as raceways, eliminate pollution and improve management systems; and
- developing applicable technologies for the culture of marine species and to guarantee the supply of high-quality aquatic products (Wang 2001).

Fishery research is still dominated by government institutions and universities, but the large economic potential of aquaculture has started to attract private sector funding for research. The interest of private companies who may fund aquaculture- and fishery-related research is mainly in the area of aquaculture feeds, chemicals for disease control, and breeding and culture technology for high-value commercial species (Hishamunda and Subasinghe 2003).

FISHERIES EXTENSION

The national fishery technology extension system was established during the 1950s, when extension stations were established in coastal areas. The stations were closed during the Cultural Revolution of the 1960s and 1970s, and only after 1978 did the government emphasize restoring the system. The National Fishery Technology Extension

Centre (NFTEC) was established in 1991 directly under the Ministry of Agriculture to (1) formulate work plans and timetables for fishery technology extension, (2) implement extension plans and programmes, (3) stipulate regulations on fishery technology extension, (4) summarize and exchange extension service experiences, (5) guide the establishment of the local fishery technology extension system, (6) specify technical standards and participate in evaluating fishery scientific research results, and (7) organize inspections of fishery technology extension projects and training activities for local extension staff (FAO 1997). NFTEC coordinates all fishery extension stations from the national to the township level. An estimated 48% of NFTEC's total annual budget of RMB384 million ($56 million) in 2000 was spent on personnel costs (Hishamunda and Subasinghe 2003).

As with education and research in the area of fisheries, extension efforts are still dominated by the public sector. Wang (2001) provides the following description of the public extension system in China:

> In order to guarantee the smooth implementation of the strategy of promoting fisheries by science and technology, both central and local governments have invested a tremendous amount of funds to establish a national aquaculture technical training and extension network consisting of extension stations at the central, provincial, prefecture, county and village levels. This extension system includes 37 stations at the provincial level, 206 at the prefecture level, 116 at the county level and 1,155 at the village level. Each station is equipped with appropriate instruments and training facilities.

These efforts to disseminate improved technologies are reflected in the large and increasing number of extension stations nationwide, which reached 13,514 in 2004, an increase of 10,000 over 1999 (FAO 2008).

The general extension mechanism of NFTEC can be grouped in the following three categories: (1) activities under the *National Fisheries Bumper Harvest Plan*, (2) regular training activities and (3) the dissemination of information through mass media (FAO 1997). Activities under the harvest plan, which depended on spreading technical innovations to boost production, were mainly on-the-spot demonstrations and the organization of technical coordination groups, whose members conduct training and write articles and newsletters. Training for fish farmers was conducted at training centres, and certificates, such as the Qualified and Skilled Fish Farmer Certificate, were awarded as incentives for participation, as certified fish farmers received priority in obtaining production contracts, technical information, extension services and loan support (ibid). In addition to newsletters, widely available mass media such as radio and television were used to disseminate information.

More recently, the private suppliers of aquaculture inputs have started providing training courses and information to their customers. Some large feed manufacturers and chemical companies hold both regular and ad hoc training courses on aquaculture techniques, the introduction of new species, fish health management, water quality control and other fish farming topics. While farmers may benefit from improved knowledge and skills, the companies use these activities to increase the amount of inputs used in aquaculture and boost their own sales. One obvious possible downside to these private extension activities, which include television advertisements, is that training providers have their own vested interests and may make input recommendations beyond levels that are economically optimal for farmers. The extension services provided by the private sector will likely become more widespread and important, covering more areas of aquaculture production (Hishamunda and Subasinghe 2003).

2.6 MARKETING OF AQUACULTURE PRODUCE AND CONSUMER PREFERENCES

Before 1979, the centrally planned economic system required that all fishery products be sold to state-owned trading companies at government-controlled prices. After 1979, a quota system was introduced under which producers had to sell a certain share of their produce to the state-owned trading companies. This system was abolished as part of the economic reforms of 1985. Since then, prices are determined by the market (FAO 1997).

Rapid economic growth, especially during the past 3 decades, has created a large and relatively wealthy middle class and subsequently higher demand for higher-value food items including seafood. The urban Chinese market for seafood grew by nearly 25% between 1996 and 2002, with a corresponding growth of 10% in the rural market. In response to expanding demand, the aquaculture sector has evolved from a narrow focus on four species dominated by carps to a diversified and commercially viable industry with dozens of species (Agri-Food Trade Service 2005). With larger quantities being produced and improvements in culture technology, prices of freshwater aquaculture products — especially of eel, soft-shelled turtle, giant freshwater prawn, mitten crab and other high-value species — have fallen by as much as half, further spurring demand. Prices for staple products such as carps have been more stable (Wang 2001). Chinese consumers currently spend 7.5% of their annual food budget on fish and seafood. The national fish and seafood market in China is expected to record further substantial growth in the future (Agri-Food Trade Service 2005).

The government promotes the marketing and trade of aquatic products by constructing wholesale markets in major production areas and aims to boost national consumption by promoting aquatic species, especially in the central and western parts of China (Yang 2005).

The preference of many Chinese consumers is to buy fish fresh, preferably alive (Hishamunda and Subasinghe 2003). This is true, especially in restaurants, despite a significant price premium for live fish (FAO 1997). That said, Hishamunda and Subasinghe (2003) report that 52.2% of national freshwater fish production was sold frozen, 10.2% dried, 3.8% smoked and 11.3% processed as fish meal. These figures indicate that the share of freshwater production sold as fresh fish is smaller than 25%.

Meanwhile, reform policies and changing market structures (especially as more urban consumers with higher incomes and less time purchase smaller quantities in supermarkets, as in other developing and transitional countries) have vitalized the country's fish-processing industry. Frozen, chilled and processed products are increasingly popular, replacing salted products. A wide range of new convenience products have been developed to match the changing profile of demand (Hishamunda and Subasinghe 2003).

The dominant distribution channels for aquaculture products in China involve a number of intermediaries, especially for the domestic market (Figure 10). While the export industry usually buys raw materials directly from producers, primary and secondary wholesalers are active in the domestic market.

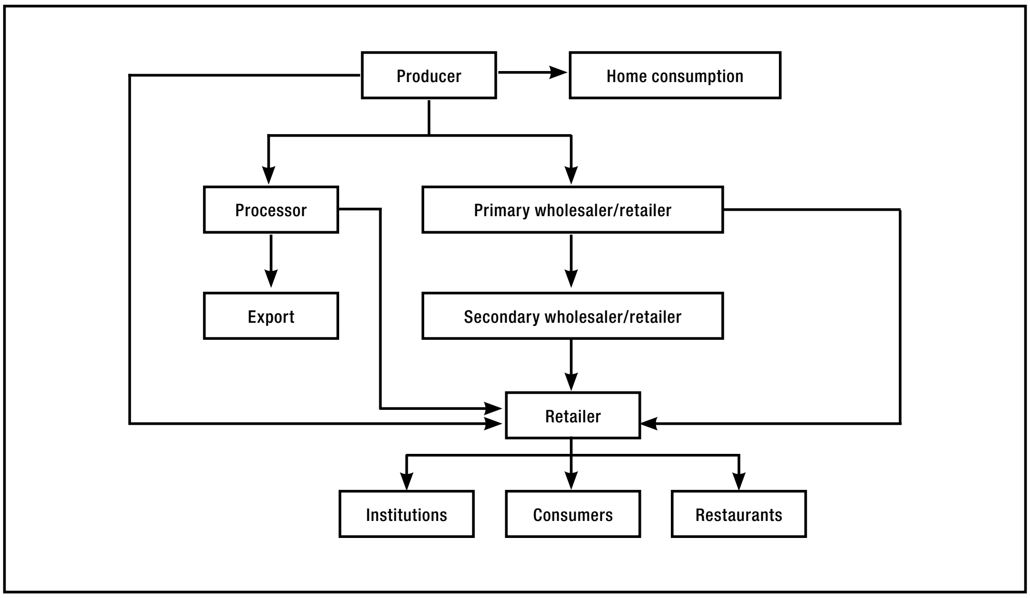
Hishamunda and Subasinghe (2003) estimate that the profit margin for each market link is at least 10-20%. This suggests that the price paid by the consumer may be around twice the farm-gate price (FAO 1997). Some producers located close to urban centres therefore have a strong incentive to sell directly to retailers, which may include supermarket chains.

Supermarkets are quickly increasing their market share in China but are still a fairly recent phenomenon there. The French supermarket chain Carrefour currently operates six stores in Beijing.

2.7 SUMMARY

China is by far the largest aquaculture producer worldwide, accounting for some 70% of global aquaculture production in 2004 and dominating export markets for aquatic products. Still, the aquaculture subsector in China is relatively small, accounting for only a fraction of the 12% that the primary sector contributed to the nation's GDP in 2006. The country is enormous and so diverse in ecological and socioeconomic conditions that huge variability within the aquaculture subsector comes as no surprise. Production systems range from commercial, highly intensive systems, both marine and

Figure 10: Distribution channels of aquaculture products in China, 2000



Source: Modified from Hishamunda and Subasinghe 2003.

freshwater, to traditional extensive systems that are integrated with the family farm and serve mainly subsistence purposes. A wide range of aquatic species is farmed. Though traditional carp-based polyculture systems still dominate, high-value species have grown in importance in recent years. There is a strong national research system at work, but a huge gap persists between the developed innovations and practices common in the field. Addressing this gap poses a significant challenge to the national extension system.

In line with the anticipated continuation of economic growth and urbanization in the country, aquaculture is expected to continue to expand. As the options to increase aquaculture production area are limited, further intensification seems to be the most likely development path.

3. OVERVIEW OF THE AQUACULTURE SUBSECTOR IN HENAN PROVINCE

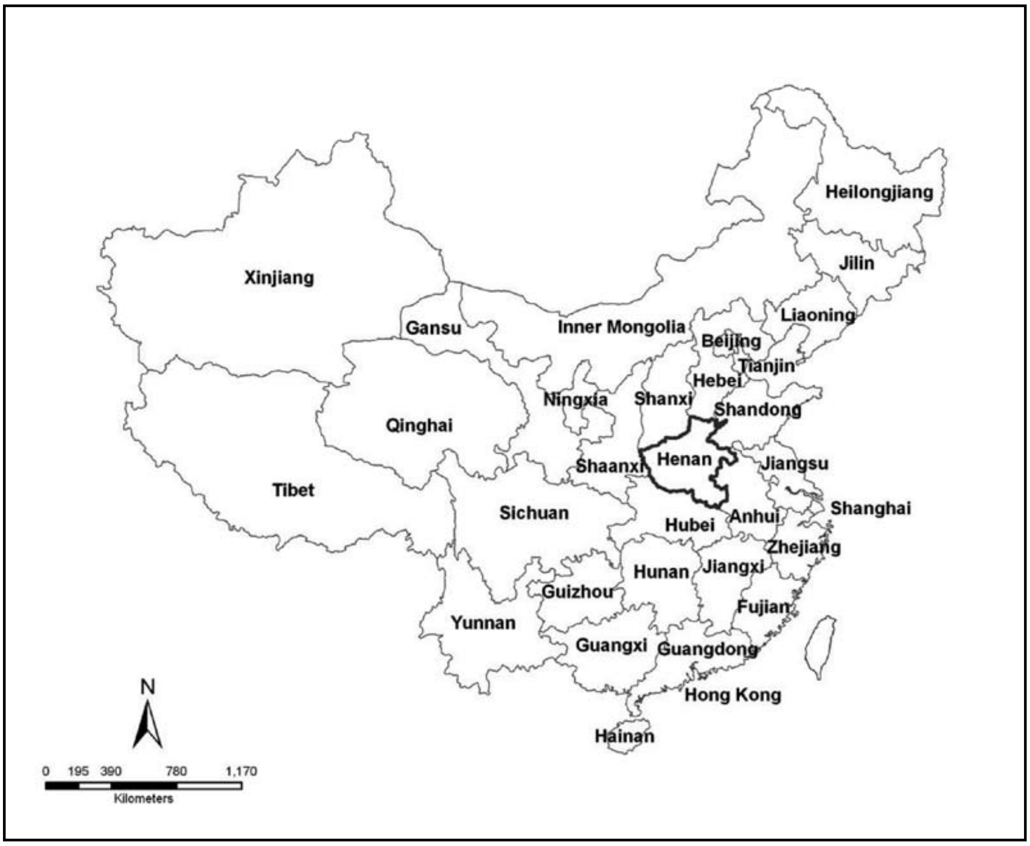
3.1 PROFILE OF HENAN PROVINCE

Henan Province, the study site for our surveys, is located in the centre of China (Figure 11). Henan was selected for the RD project mainly because it is average in terms of both economic and aquaculture development and thus representative of China. In addition, a wide range of aquaculture production systems, from integrated extensive to intensive, is practiced there. The province is the most populous in China and has a high population density of 569 people/km^2, yet in 2004 a very high 77% of the population of some 97 million lived in rural areas.

In terms of its geography, Henan is flat in the east and mountainous in the west and extreme south (Figure 12). The major river is the Yellow River (Huang He), which enters the province in the northwest and flows across the north.[2] A peculiar feature of the Yellow River in the eastern part of the province is that natural sedimentation and artificial levees have raised the riverbed to a higher elevation than the surrounding land. This has favourable implications with regard to the availability of surface and groundwater to areas close to the river and is thus highly important to aquaculture production.

Henan has a many smaller rivers including the Huai He and Hai He and a number of

Figure 11: The provinces and autonomous regions of China



2 The name Henan means "south of the river".

reservoirs. The region is characterized by a temperate continental climate, with most of the precipitation occurring during the summer months of July and August. The average temperature is around or just below 0°C in January and as high as 28°C during the summer (Wikipedia 2008).

The table in Annex 9 gives an overview of a number of key indicators for Henan and shows how these figures compare with the situation in the rest of the country. Henan is one of China's less economically developed provinces, with a GDP per capita of US$1,110 in 2003. It is an agricultural province, not only in terms of the large rural population but also of the dependence of 80% of the population in 2003 on agriculture for income and employment. The province is the largest producer of sesame and wheat in China and ranks third among all provinces in terms of grain production. Aquaculture and fisheries accounted in 2003 for only 1.34% of the provincial GDP derived from agriculture and only 0.23% of the total GDP. As elsewhere in China, wages in the fishery sector are higher than agricultural wages. In 2003, the average staff and worker wage was $795 in agriculture and $1,078 in fisheries (CSP 2004).

Aquaculture accounted for 93.3% of aquatic products produced in Henan in 2003, up from 89.5% in 1990. The major products are various species of finfish, but the shares of higher-value species such as shrimp and crab have increased in recent years (Table 8).

The two major production environments for aquaculture in Henan are ponds and reservoirs, with ponds accounting for 48% of the total area used for fish culture in 2003 and reservoirs 49% (Table 9). However, ponds are the most productive, accounting in 2003 for 82% of Henan's aquaculture production (Annex 9). Table 10 shows the regional spread of the production of aquatic products within Henan. The two areas that were selected for the household survey presented in section 3.3 are Zhengzhou, on the Yellow River, and Xinyang, in the south, both of which are major producers of aquatic products.

Table 8: Major aquatic products in Henan, 1990-2003

Production of aquatic products ('000 t)	1990	1995	2000	2002	2003
Total (capture and culture)	**104.75**	**180.94**	**321.66**	**362.18**	**389.50**
Capture	10.90	11.80	19.42	21.48	26.16
Finfish	na	9,20	12.34	18.33	22.67
Shrimp, prawn and crab	na	1,70	5.37	2.40	2.78
Mollusc and other	na	0.90	1.69	0.76	0.71
Culture	93.80	169.10	302.26	340.70	363.34
Finfish	na	167.60	298.43	329.64	353.45
Shrimp, prawn and crab	na	0.60	1.25	7.31	7.48
Mollusc and other	na	0.90	2.58	3.76	2.40

na = not available, t = tonne.
Source: CSP 2004.

Table 9: Area of fish culture by ecosystem in Henan, 1990-2003

Area of fish culture by ecosystem	1990	1995	2000	2002	2003
Total area ('000 ha)	**161.80**	**174.30**	**189.15**	**198.20**	**200.29**
Ponds ('000 ha)	70.80	82.20	91.65	94.66	95.20
Lakes ('000 ha)	3.70	3.60	2.90	2.83	2.83
Reservoirs ('000 ha)	81.60	84.80	90.40	96.23	97.21
Diked areas ('000 ha)	3.90	3.20	3.60	3.62	3.98
Others including rivers ('000 ha)	1.80	0.50	0.60	0.86	1.07

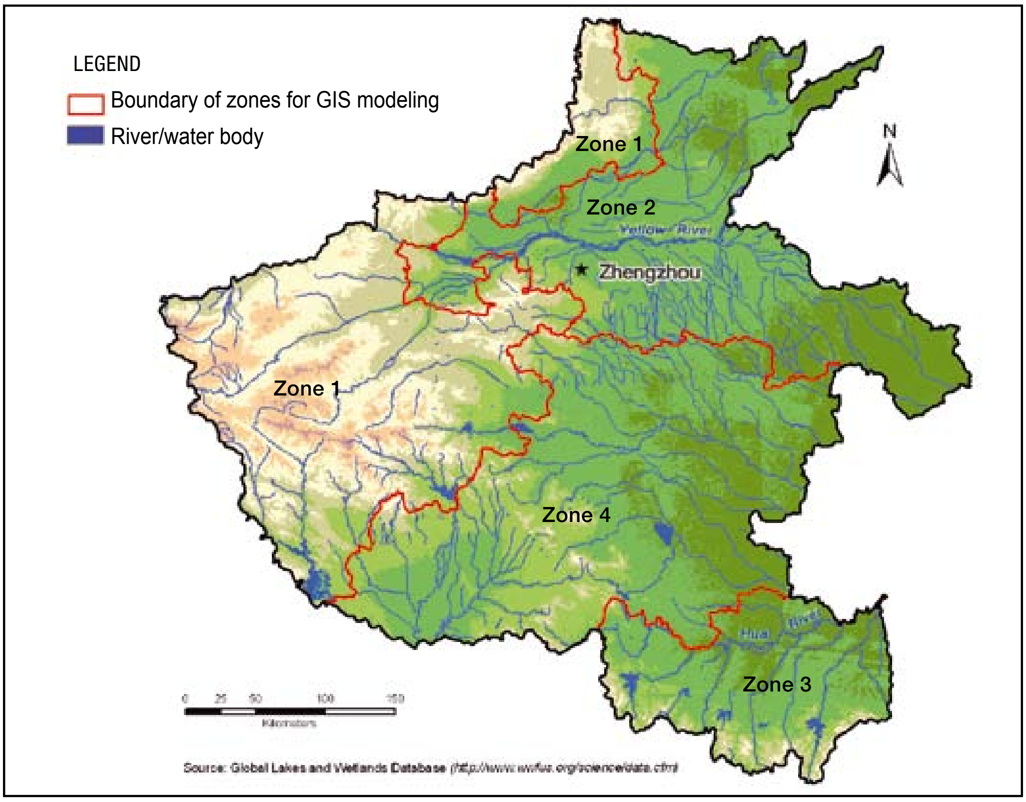
ha = hectare.
Source: CSP 2004.

Table 10: Aquatic production in Henan by prefecture, 2003

Prefecture	Area under aquatic culture ('000 ha)	Aquatic production by source ('000 t)			Aquatic production by type ('000 t)		
		Total	Capture	Culture	Fish	Shrimp, prawn, crab	Mollusc and other
Total	**200.29**	**389.50**	**26.16**	**363.34**	**376.12**	**10.26**	**3.12**
Zhengzhou	6.32	61.58	0.23	61.36	61.45	0.06	0.07
Kaifeng	3.43	14.43	0.53	13.90	14.21	0.05	0.18
Luoyang	12.44	12.65	0.47	12.18	12.64	0.01	<0.01
Pingdingshan	12.55	8.11	0.17	7.94	7.85	0.18	0.08
Anyang	1.11	2.76	0.15	2.61	2.75	0	<0.01
Hebi	0.69	2.73	0.31	2.42	2.68	0.03	0.02
Xinxiang	3.21	18.63	1.06	17.57	18.61	<0.01	0.02
Jiaozuo	1.24	5.03	0.05	4.98	5.00	<0.01	0.02
Puyang	1.49	5.67	0.31	5.36	5.64	0.03	0
Xuchang	2.00	4.97	0.29	4.68	4.88	0.05	0.03
Luohe	1.39	4.52	0.55	3.97	4.40	0.05	0.08
Sanmenxia	1.81	2.25	0.50	1.75	2.24	<0.01	<0.01
Nanyang	45.12	60.08	2.63	57.45	55.87	3.68	0.52
Shangqiu	6.96	25.87	0.88	24.99	25.29	0.27	0.31
Xinyang	63.24	99.00	10.62	88.37	92.99	4.60	1.41
Zhoukou	7.47	21.19	2.89	18.30	20.84	0.24	0.11
Zhumadian	29.72	35.05	3.55	31.50	33.86	0.94	0.25
Jiyuan	0.11	5.00	1.00	4.00	4.93	0.07	0.01

ha = hectare, t = tonne.
Source: CSP 2004.

Figure 12: Aquaculture zones of Henan Province



GIS = geographic information system.

Capture fisheries are of minor importance in most of Henan, and there is very little aquatic production other than finfish. Only two prefectures, Nanyang and Xinyang, are noteworthy for their production of shrimp, prawn and crab.

For the geographic information system (GIS) modelling work conducted in Henan under the RD project, the province was divided into four aquaculture zones according to the availability of water and land, existing infrastructure, and dominant type of pond system, extensive versus intensive. Figure 12 shows the four zones, which were determined by national partners, mainly staff of the provincial Bureau of Fisheries and county-level fishery extension officers. A brief characterization of the zones, based on information provided by Bureau of Fisheries staff, is provided to explain and justify the major criteria for this classification.

Zone 1: The **western hilly** zone encompasses 33 counties, nine of which are located in the Taihang mountains of the northwest and 24 of which are located in the Qinling mountains of the west. There are few sources of water in this area, and the potential for pond development is limited. In this zone, pond aquaculture development started late and the level of culture technology is relatively low.

Zone 2: The **Huangwei plain** is part of the Huang He (Yellow River), Huai He and Hai He plain, encompassing 44 counties. A major fish-farming industry developed at the end of the 1980s along the Yellow River. The ponds were initially used to produce carps, but since 2000 the species structure has gradually shifted toward higher-value products. Water can be sourced from the rivers, and a relatively large area is available for pond construction. Production in this zone is generally of higher intensity than elsewhere in Henan.

Zone 3: The zone **south of the Huai He** is also part of the Huang He, Huai He and Hai He plain and includes nine counties. The natural conditions of this area are intermediate between those of Zones 2 and 4. The area is subtropical, with a warm and humid climate, adequate sunlight, high rainfall, and a lot of rivers and reservoirs. Fish is a popular food here. Previously, the main species produced were silver carp and bighead carp, but since 2000 a shift toward higher-value species has occurred. Ponds are scattered and generally cover a large area. The most common form of production is the traditional polyculture system of silver and bighead carp.

Zone 4: The zone **between the Huang He and the Huai He** consists of 40 counties and is located between the Huang He, Huai He and Hai He plain and the Nanyang basin. The natural conditions of this area are intermediate between those of Zones 2 and 3. The zone has suitable areas for pond development along its rivers, and existing holes excavated for material to make bricks in the eastern part of this zone can be used as ponds. The intensity of fish culture is considered average or medium compared with the overall situation in the province.

3.2 FINDINGS OF THE COUNTY-LEVEL SURVEY IN HENAN

Because of the paucity of disaggregated data with regard to the fishery sector, a county-level survey was conducted under the RD Project. Data from 2005 was collected from 124 counties covering the whole of Henan in a survey implemented in 2006 by the Henan Bureau of Fisheries with backstopping from CAFS and the WorldFish Center. This section of the report presents the findings of the survey.

We start with an overview of key indicators of Henan disaggregated for the four identified aquaculture zones. There are a number of marked differences among the zones, which is not surprising, as the zones were determined by considering the availability of land and water, infrastructure, and in particular divergent features of the aquaculture subsector. Population density is highest in Zones 2 and 4, where the major urban centres are located, while the hilly Zone 1 and the remote Zone 3 are less densely populated (Table 11). The average annual per capita income is highest in the relatively urban Zone 2, at $602, with comparable figures of $513 in Zone 1,

$431 in Zone 3 and $461 in Zone 4. These figures are well below the national average income, indicating Henan's relatively low level of economic development.

Average per capita incomes vary greatly among the counties within one zone based on the income quartiles of Henan counties. Figure 13 shows the share of counties in each zone falling into each of the income quartiles of Henan Province. Zone 4 has the highest share of counties with per capita incomes in the lowest quartile, while Zones 2 and 1 have the largest share of "rich" households. There is high income inequality within Henan, with 80% of the counties earning less than half the average income of the top 10%. This is typical of the early stages in economic development.

KEY FISHERY INDICATORS OF HENAN BY ZONE

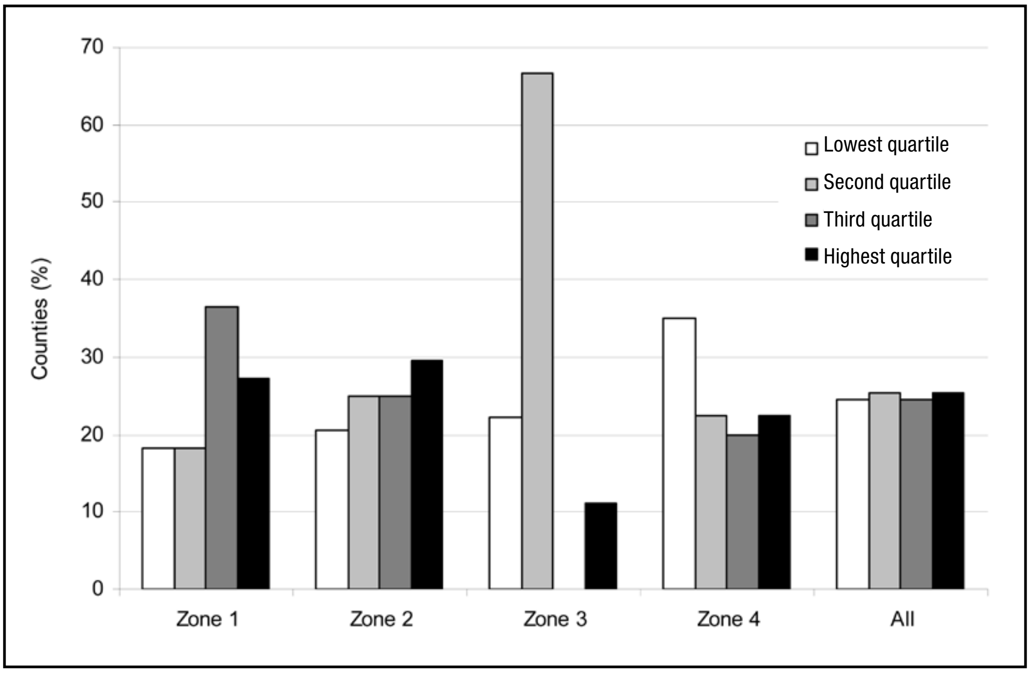
Henan has about 128,000 households involved in fish production, out of which 89% practise aquaculture (Table 11). Capture fisheries account for only 8% of Henan's total fish production (Table 12). Zone 3, south of the Hai He, has the largest absolute number of fisher and fish-farming households (Table 11), but even in this area the share of fishing households in the total number of households is only around 2.4%, assuming an average family size of 4. The percentage shares for the other three zones are even lower, as the total population of them is larger.

Table 11: Key indicators of Henan by aquaculture zone, 2005

Indicator	Aquaculture zones				All
	Zone 1	Zone 2	Zone 3	Zone 4	
Land area ('000 sq km)	53.62	42.21	18.92	52.07	166.81
Population 2005 (million people)	18.72	35.58	8.04	37.19	99.53
Population density (people/sq km)	349	843	425	714	597
Per capita income ('000 RMB/year)	3.5	4.1	2.9	3.1	3.5
Number of agriculture households (million)	3.92	6.83	1.74	7.76	20.25
Number of fish farming households ('000)	6.38	22.45	43.51	41.35	113.70
Number of fisher households ('000)	2.63	2.18	4.82	4.45	14.08
Fishing HH as share of agricultural HH (%)	0.23	0.36	2.78	0.59	0.63
Total number of ponds ('000)	6.59	51.91	130.91	86.35	275.75
Total pond area ('000 ha)	4.66	19.45	29.61	29.85	83.57
Size of ponds (ha)	0.71	0.37	0.23	0.35	0.30
Total fish production ('000 t)	65.3	242.5	116.6	111.0	535.4
Number of commercial fish enterprises[a]	46	250	211	80	587
Size of commercial fish enterprises (ha)	19.07	32.62	21.30	27.13	26.74
Number of towns	446	661	179	668	1,954
Number of wholesale fish markets	58	90	55	110	313
Number of cold storage facilities for fish	25	44	33	27	129
Total capacity of cold storage facilities (t)	9,865	199,086	3,715	5,470	218,136
Number of fish nurseries	46	87	211	126	470
Number of hatcheries	49	1,170	21	179	1,419
Number of aquaculture technicians	86	228	116	185	615
Number of pond aquaculture workers	6,456	25,489	27,038	43,712	102,695
Pond area per worker (ha/person)	0.72	0.76	1.10	0.68	0.81

ha = hectare, HH = households, RMB = renminbi, sq km = square kilometre, t = tonne.
[a] Commercial fish enterprises are defined as having >50 *mu* (3.3 ha) in mountain regions and >100 *mu* (6.6 ha) in the plains.
Source: WorldFish-CAFS county survey in 2006.

Figure 13: Per capita income quartile of Henan counties distributed among the zones, 2005



Source: WorldFish-CAFS county survey in 2006.

A larger number of households are involved in fishing and aquaculture-related activities such as producing feed and seed, and trading, processing and marketing fish. Counties within a single zone show wide variation in their number of fishery households, pointing to differences in the availability of fishery resources and their use in fish culture, depending on specific farming systems, the level of intensification, infrastructure, and access to inputs and markets. Its higher intensity of aquaculture production makes Zone 2 the major fish producer, accounting for 45% of Henan's total production (Table 12).

Table 12: Key fishery indicators in Henan by aquaculture zone, 2005

Indicator	Aquaculture zones				All
	Zone 1	Zone 2	Zone 3	Zone 4	
Total fish production (t)	65,340	242,477	116,585	111,013	535,415
Total cultured fish production (t)	53,489	238,969	100,754	103,819	497,031
Cultured fish production (% of total)	81.9	98.6	86.4	93.5	92.8
Aquaculture production of ponds (t)	20,143	188,987	83,191	81,181	373,502
Privately owned pond production (%)	80.1	88.9	84.5	93.0	88.3
Other aquaculture production (t)	33,346	49,982	17,563	22,638	123,529
Pond share of total production (%)	30.8	77.9	71.4	73.1	69.8
Cultured ponds (number)	5,330	40,338	109,863	73,546	229,077
Number of privately owned ponds (%)	94.1	95.5	83.2	96.5	89.9
Uncultured ponds (number)	1,258	11,569	21,045	12,799	46,671
Uncultured pond area (ha)	610	4,035	3,625	5,420	13,689
Total cultured pond area (ha)	4,045	15,418	25,988	24,426	69,877
Area of privately owned ponds (%)	72.1	90.6	87.7	91.6	88.7
Average size of cultured ponds (ha)	0.76	0.38	0.24	0.33	0.31
Average size of all ponds (ha)	0.71	0.37	0.23	0.35	0.30
Fish yield in ponds (t/ha)	4.98	12.26	3.20	3.32	5.35
Yield in privately owned ponds (t/ha)	5.53	12.02	3.08	3.37	5.32

ha = hectare, t = tonne.
Source: WorldFish-CAFS county survey in 2006.

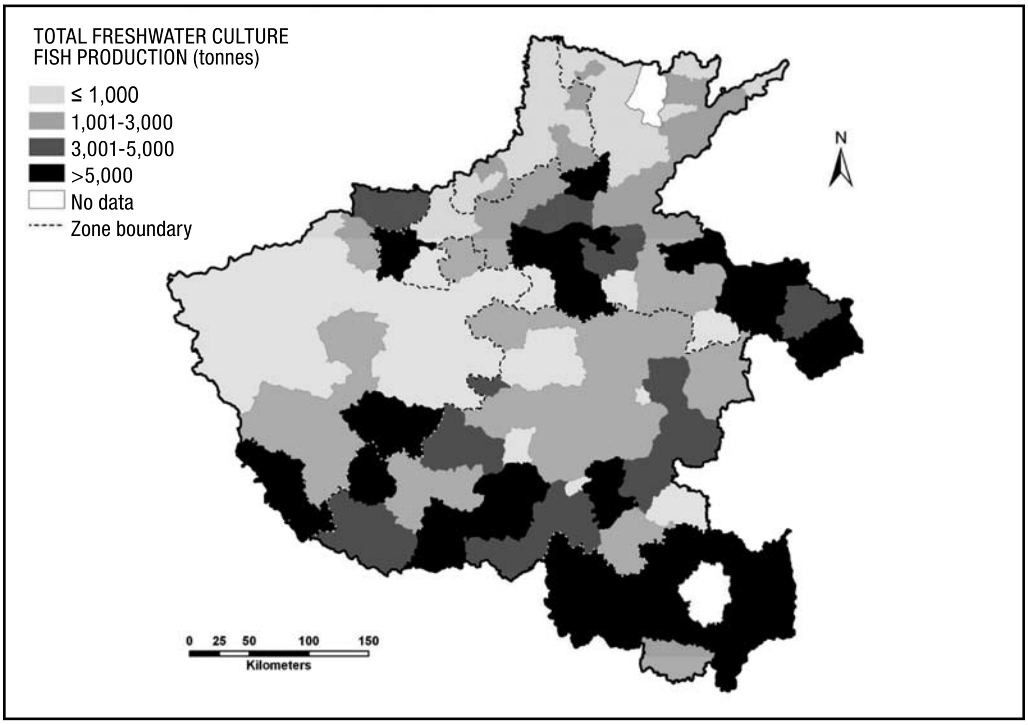
Within the zones, specific counties account for most of the culture fish production (Figure 14). For example the areas with reservoirs in the south of Zone 1 are along the major rivers.

Zone 2 is a hub for marketing and trading fish, with the second largest number of wholesale fish markets and 91% of cold storage capacity (Table 11). The whole province has 129 cold storage facilities for fish with a total capacity of 218,316 t.

Pond production occupied in 2005 a 78% share of total fish production in Zone 2 and a 70% share in Henan in general. Ponds account for 38% of total aquaculture production in Zone 1, 79% in Zone 2, 83% in Zone 3, and 78% in Zone 4. Figure 15 illustrates the dominance of the pond production environment and indicates there are some counties in the southern part of Henan (distributed in Zones 1, 3 and 4) that produced over 5,000 t of fish in culture systems other than ponds (see Figures 14 and 15). The fish yield in aquaculture production environments other than ponds is on average only half that realized in ponds.

There are two ownership arrangements in the area: collective and private, with 88% of pond area privately owned and producing a corresponding share of the total pond production. Our survey found no major difference in the yield of collectively and privately owned ponds. The average fish yield in ponds in Henan is 5.35 t/ha, but there are large differences among the four zones, with yields ranging from only 3.3 t/ha to 12.3 t/ha (Table 12). These differences in yield help explain high fish production in Zone 2 despite the relatively low number of counties with large cultured fish industries (Figure 14 and Table 12).

Figure 14: Total freshwater culture production in Henan by county, 2005

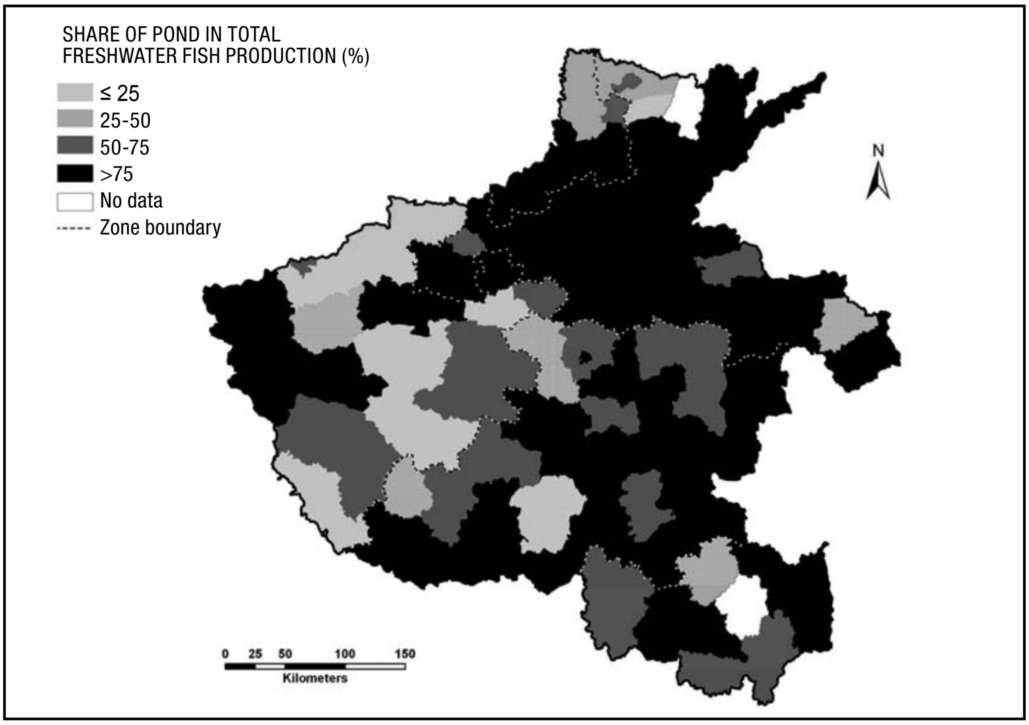


Source: WorldFish-CAFS county survey in 2006.

MAJOR AQUACULTURE SPECIES CULTURED

As in the national picture described in the second chapter of this report, the production of various carp species is very prominent in Henan. Carps were usually named among the five most important species for aquaculture. Bureau of Fisheries officers in about 85% of the surveyed counties listed one of the five major carp species as the most important aquaculture species in terms of production volume (Figure 16). Silver carp and common carp are the dominant species, accounting

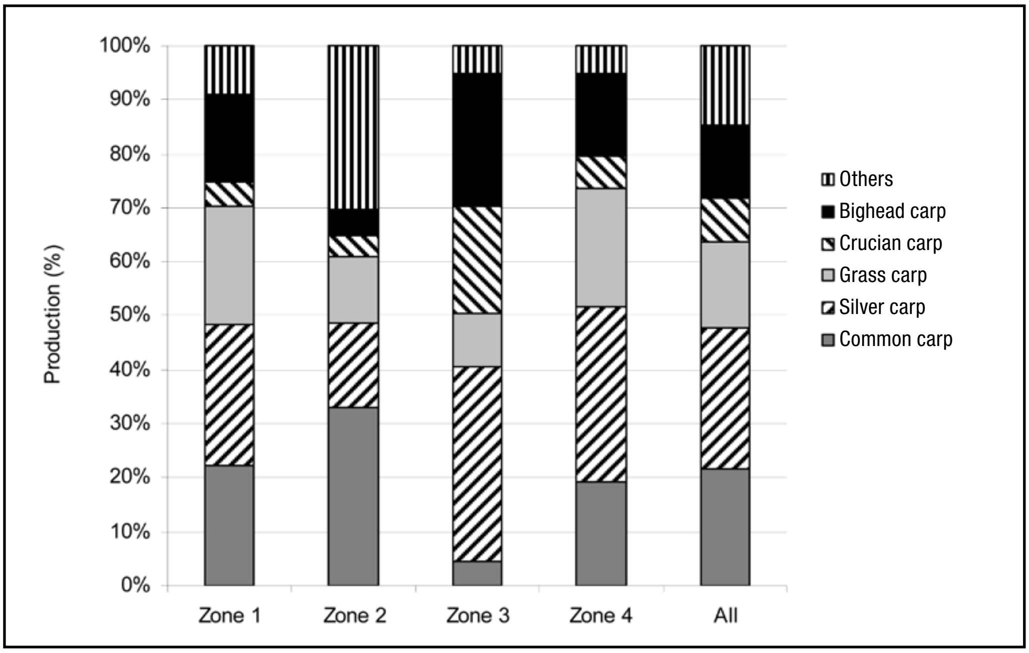
Figure 15: Share of ponds in total freshwater fish production in Henan by county, 2005



Source: WorldFish-CAFS county survey in 2006.

for almost half of fish production in Henan, but with significant variation among zones. Only a few other species are listed as being of major importance. An exception was Zone 2, where 30% of production was of such higher-value species as shrimp, crab and mandarin fish, and/or such speciality species as turtle and frog.

Figure 16: Most-produced species in counties of Henan by zone, 2005



Source: WorldFish-CAFS county survey in 2006.

In 2005, an estimated 307,108 t of carp (mainly common, bighead, crucian and grass carp, see Annexes 1 and 2) were produced in the province, accounting for most of the cultured fish production in Henan (Table 13). Table 13 is derived from the compiled production figures of the five most important species in each of the counties, thus deviating from the overall production figure given in Table 12. This procedure biases the picture in favour of the major species, as less common aquaculture products are not listed and thus are underestimated. This puts the very low share of other species reported in Table 13 in perspective.

It is remarkable, however, that in Zone 2 a significant share of the production, 30%, is other than the five major species, consisting mainly of higher-value species. In the other three zones, the species produced are more mainstream, with a strong focus on several carp species.

FISH SEED PRODUCTION AND LOCATION OF HATCHERIES

Apart from being the major fish production area in Henan, Zone 2 is also a centre for producing fish seed, with some 82% of the province's hatcheries (Table 11). The county-level survey counted 1,419 hatcheries, both public and private, operating an area of 195 ha (Table 14). In addition, there were 470 nurseries in Henan in 2005, nursing fish fry into fingerlings (Table 11). The government operated 80% of the hatcheries, but this percentage varied by aquaculture zone (Table 14). Only in Zone 2 were most hatcheries government operated.

Table 13: Major species production and share of Henan fish production, 2005

Major species	Aquaculture zone				All zones	Share of total (%)
	Zone 1	Zone 2	Zone 3	Zone 4		
Silver carp	11,919	21,043	27,593	34,289	94,844	26.66
Common carp	9,278	44,534	2,684	20,059	76,555	21.52
Grass carp	10,859	16,856	7,748	23,440	58,903	16.56
Bighead carp	7,745	6,183	19,171	16,184	49,283	13.86
Crucian carp	1,865	4,570	13,590	5,430	25,455	7.16
Catfish (Whitespotted *Clarias*)	1,358	725	59	0	2,142	0.60
Black carp	171	0	1,471	426	2,068	0.58
Blunt snout bream	23	138	650	808	1,619	0.46
Icefish (family *Salangidae*)	397	205	0	100	702	0.20
Loach	0	650	0	0	650	0.18
Tilapia	26	172	0	0	198	0.06
Salmon	107	0	0	0	107	0.03
Others	562	39,156	600	2,858	43,176	12.13
Total	**44,310**	**134,232**	**73,566**	**103,594**	**355,702**	**100.0**

Source: WorldFish-CAFS county survey in 2006.

Table 14: Indicators of fish seed production in Henan by zone, 2005

Indicator	Aquaculture zone				All
	Zone 1	Zone 2	Zone 3	Zone 4	
Total number of hatcheries	49	1,170	21	179	1,419
Counties without fry production (%)[a]	67	46	33	63	56
Government-owned hatcheries (%)	48.98	93.85	23.81	36.87	80.14
Hatchery area (ha)	23.3	62.5	35.5	73.3	194.6
Average hatchery area (ha)	0.47	0.05	1.69	0.41	0.14
Fry production ('000)	19.15	133.06	43.95	2,587.87	2,784.03
Spawn production (t)	2.26	397.06	16.54	659.00	1,074.86

ha = hectare, t = tonne.
[a] Some may have fry production but did not report it.
Source: WorldFish-CAFS county survey in 2006.

Elsewhere, especially in Zones 3 and 4, most were private enterprises. While there was a larger concentration of hatcheries in Zone 2, their average size in this zone was much smaller, at 0.05 ha, than in the other three zones, which had average hatchery areas of around half a hectare or larger. All hatcheries in Henan together produced 1,075 t of spawn and about 2.8 million finfish fry in 2005 (Table 14). As can be expected from the share of different species in overall production, most of the fish seed produced is spawn of the major carps. Table 15 shows the production of fish seed disaggregated by major species.

Almost 90% of all spawn produced is of common and silver carp. Most hatcheries specialize in only one species rather than producing a range of seed (Table 16). When considering hatchery area, however, the multi-species hatcheries account for a significant 35% share of the total. It is therefore difficult to assess the supply situation for seed of species other than the major carps. At the same time, infrastructure and transport technology are good in many parts of China, so that grow-out operators in good locations, especially in Zone 2, can likely import seed from other provinces relatively easily.

Table 15: Production of finfish spawn and fry in Henan by major species, 2005

Major species	Spawn production		Fry production	
	kg	Share (%)	Number	Share (%)
Black carp	20,120	1.87	1,000	0.04
Grass carp	51,767	4.82	53,746	1.93
Silver carp	411,180	38.25	52,583	1.89
Bighead carp	20,133	1.87	31,165	1.12
Common carp	548,222	51.00	64,104	2.30
Crucian carp	39	0.00	14,357	0.52
Wuchang bream	5,000	0.47	1,300	0.05
Channel catfish	0	0.00	60	0.00
Tilapia	0	0.00	465	0.02
Huanghe common carp	0	0.00	30,003	1.08
Others (multi-species)	18,400	1.71	2,535,242	91.06
Total	**1,074,861**	**100.00**	**2,784,025**	**100.00**

kg = kilogram.
Source: WorldFish-CAFS county survey in 2006.

Table 16: Number and area of hatcheries in Henan by major species, 2005

Major species	Number of hatcheries			Total hatchery area (ha)	Share of total hatchery area (%)
	Government	Private	Total		
Black carp	na	na	na	na	na
Grass carp	17	38	55	20.53	10.5
Silver carp	19	32	51	14.80	7.6
Bighead carp	14	19	33	13.89	7.1
Common carp	1,094	74	1,168	57.47	29.5
Crucian carp	24	31	55	18.33	9.4
Wuchang bream	3	1	4	1.20	0.6
Channel catfish	2	0	2	0.13	0.1
Tilapia	0	1	1	0.13	0.1
Huanghe common carp	0	2	2	1.01	0.5
Others (multi-species)	20	28	48	67.51	34.6
Total	**1,193**	**226**	**1,419**	**195.00**	**100.00**

ha = hectare, na = not available.
Source: WorldFish-CAFS county survey in 2006.

Figure 17 shows the geographic distribution of fry production in the province. Many counties, 56%, reported no fry production (Table 14). The major production areas are located in Zones 2, 3 and 4, in or near the major production areas for freshwater cultured fish (Figure 14). However, fish seed is generally traded widely within provinces, and especially high-value species seed commonly travels great distances in China.

STATUS AND TRENDS OF FISH PRICES

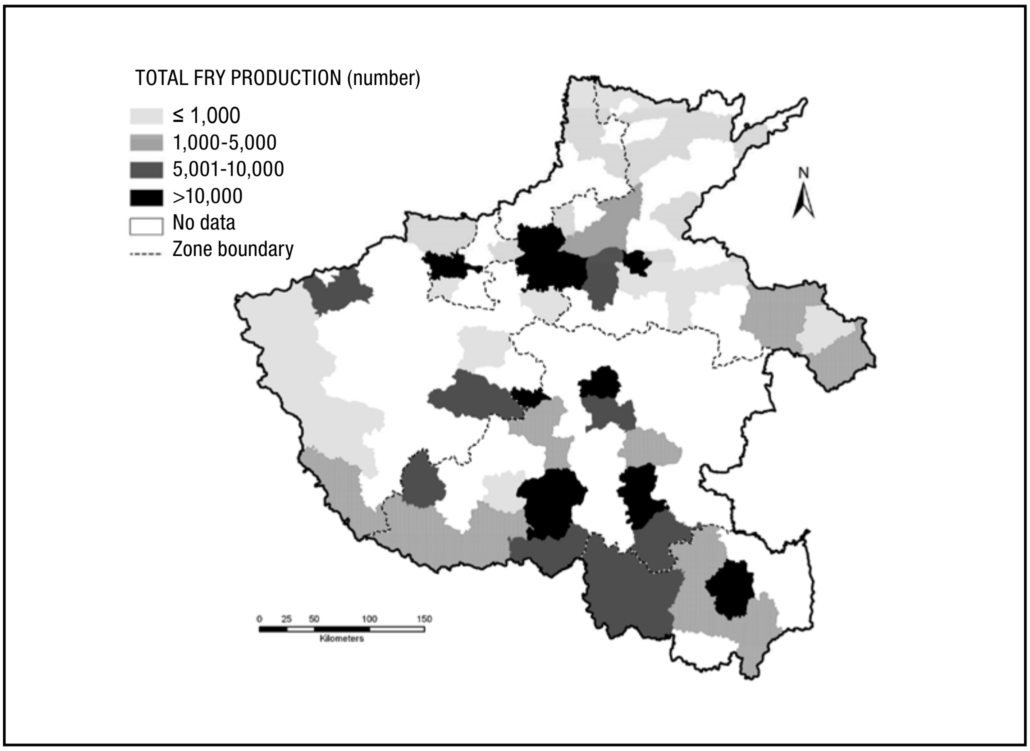
Farm-gate and retail prices for the major fish species were also collected for 2005. County fishery officers recorded the average or normal local market price per kilogram of individual fish weighing less than 1 kilogram and for fish weighing 1 kilogram or more. In addition, the lowest and highest prices obtained during 2005 were recorded. Tables 17 and 18 show the normal or average prices of the two different sizes of fish at the farm gate and retail. The lowest and highest prices were converted into percentage deviation from the average price in 2005 and are reported as well. These figures indicate the extent of price fluctuations due to seasonality or other shortages in supply or peaks in demand, for example during Chinese New Year.

The most expensive species of the most common fish are tilapia and snakehead, which fetch prices almost twice as high as the most common carp species (Tables 17 and 18). Silver carp, which is the second most commonly produced fish species, was the lowest priced, both at the farm gate and retail.

Some species, such as Wuchang bream, snakehead and especially predatory carps, fetch much higher retail than farm-gate prices. This higher price margin may be eaten up by more complicated and expensive transport or storage requirements or simply longer transport distances. Within the group of carps, the retail market price margin is, by comparison, similar and narrow.

The collected information reveals considerable fluctuations in prices for all species, but especially high variability for predatory carps. Grouping the farm-gate price of the three major species — common carp, silver carp and grass carp — of less than 1 kg and price fluctuation by zone (Table 19) reveals

Figure 17: Total fish fry production in Henan by county, 2005



Source: WorldFish-CAFS county survey in 2006.

Table 17: Farm-gate price and intra-annual price changes of fish < 1 kg and ≥ 1 kg for selected species in Henan, 2005

Species	Price of fish weighing < 1 kg			Price of fish weighing ≥ 1 kg		
	Normal price (RMB/kg)	Deviation from normal price (%)		Normal price (RMB/kg)	Deviation from normal price (%)	
		Decrease	Increase		Decrease	Increase
Black carp	6.67	-20.71	24.29	8.67	-14.90	25.48
Grass carp	6.68	-12.22	9.47	7.61	-14.99	9.28
Silver carp	3.61	-14.33	14.22	4.60	-16.62	13.28
Bighead carp	4.79	-12.94	11.79	6.23	-18.91	13.40
Common carp	5.94	-13.20	9.66	6.51	-14.90	10.46
Crucian carp	8.16	-17.99	19.36	8.86	-21.02	12.38
Wuchang bream	7.95	-16.39	10.25	9.08	-14.87	11.17
Catfish (whitespotted *Clarias*)	5.21	-10.40	15.20	6.27	-12.32	10.80
Tilapia	11.57	-17.28	8.64	12.00	-16.67	8.33
Snakehead	10.50	-9.52	4.76	14.00	-10.71	14.29
Predatory carp	5.50	-45.45	36.36	12.50	-28.00	20.00

kg = kilogram, RMB = renminbi.
Source: WorldFish-CAFS county survey in 2006.

Table 18: Retail price and intra-annual price changes of fish < 1 kg and ≥ 1 kg for selected species in Henan, 2005

Species	Price of fish weighing < 1 kg			Price of fish weighing ≥ 1 kg		
	Normal price (RMB/kg)	Deviation from normal price (%)		Normal price (RMB/kg)	Deviation from normal price (%)	
		Decrease	Increase		Decrease	Increase
Black carp	7.38	-9.60	22.03	9.88	-10.31	18.99
Grass carp	7.42	-11.92	9.27	8.51	-14.25	11.46
Silver carp	4.31	-17.37	11.65	5.32	-16.77	13.98
Bighead carp	5.57	-12.56	12.46	7.18	-15.57	16.08
Common carp	6.62	-13.61	10.19	7.27	-13.56	11.07
Crucian carp	8.75	-15.94	16.92	9.18	-16.55	19.02
Wuchang Bream	10.19	-15.11	8.35	11.75	-10.92	15.18
Catfish (whitespotted *Clarias*)	6.83	-13.88	11.44	7.58	-15.07	10.53
Tilapia	12.33	-13.51	6.76	13.00	-11.54	7.69
Snakehead	15.00	-8.89	6.67	15.50	-6.45	9.68
Predatory carp	10.00	-40.00	40.00	13.00	-23.08	23.08

kg = kilogram, RMB = renminbi.
Source: WorldFish-CAFS county survey in 2006.

that price variability is as high within the respective zone as it is overall, indicating that seasonal fluctuation at, for example, Chinese New Year and possibly a gradient between urban and rural markets are important determinants of the price, while the location within a specific aquaculture zone seems to be less important. The overall price variation is lower for silver carp — the fish most produced, as shown in Table 13 — than for common carp, followed by grass carp, which indicates supply response to the changes in the market price of fish. However, the degree of variance in the minimum to maximum price among counties and across zones indicates a disequilibrium in price and imperfect distribution of markets from one zone to other.

In addition to providing price figures, county fishery officers assessed the general level of 2005 prices against prevailing prices in the previous 5 years. Table 20 presents by aquaculture zone, and Figure 18 by county, the expert assessment of 2005 fish prices relative to the prevailing market prices from

Table 19: Farm-gate price for fish < 1 kg and intra-annual price changes of major species in Henan by zone, 2005

Indicator	Aquaculture zone				All
	Zone 1	Zone 2	Zone 3	Zone 4	
Common carp	N = 30	N = 37	N = 5	N = 34	N = 106
Minimum price (RMB/kg)	4.80 (1.0)	5.33 (1.0)	4.50 (1.0)	5.46 (2.0)	5.17 (1.4)
Normal price (RMB/kg)	5.69 (1.3)	5.81 (1.2)	4.60 (1.7)	6.36 (1.9)	5.89 (1.5)
Maximum price (RMB/kg)	6.60 (2.7)	6.52 (1.4)	6.50 (1.3)	6.71 (2.5)	6.59 (2.1)
Variance	3.65	1.69	2.47	4.59	3.01
Silver carp	N = 31	N = 36	N = 8	N = 35	N = 110
Minimum price (RMB/kg)	2.67 (1.0)	2.87 (1.0)	3.57 (1.4)	3.48 (1.5)	3.03 (1.2)
Normal price (RMB/kg)	3.03 (1.1)	3.20 (1.0)	4.57 (0.8)	3.88 (1.5)	3.46 (1.3)
Maximum price (RMB/kg)	3.56 (1.4)	3.68 (1.1)	5.29 (1.8)	4.64 (1.6)	4.03 (1.5)
Variance	1.45	1.11	2.26	2.45	2.16
Grass carp	N = 31	N = 36	N = 8	N = 35	N = 108
Minimum price (RMB/kg)	5.76 (1.7)	6.19 (1.6)	4.29 (1.5)	5.64 (2.4)	5.76 (1.9)
Normal price (RMB/kg)	6.66 (2.0)	6.65 (1.6)	5.83 (1.3)	6.23 (1.9)	6.47 (1.8)
Maximum price (RMB/kg)	7.16 (2.4)	7.35 (2.0)	6.43 (2.4)	7.09 (2.4)	7.15 (2.2)
Variance	4.36	3.27	3.95	4.95	4.50

kg = kilogram, N = number of counties reporting, RMB = renminbi
Note: Figures in parentheses are standard deviations.
Source: WorldFish-CAFS county survey in 2006.

Table 20: Changes in fish price in Henan comparing 2005 prices against average prices of preceding 5 years by aquaculture zone

Fish price in 2005 compared with the previous 5 years	Aquaculture zone				Total (N = 126)
	Zone 1 (N = 33)	Zone 2 (N = 44)	Zone 3 (N = 9)	Zone 4 (N = 40)	
Decreased (% counties)	30.3	36.4	0.0	32.5	31.0
No change (% counties)	18.2	27.3	22.2	20.0	22.2
Increased (% counties)	51.5	36.4	77.8	47.5	46.8

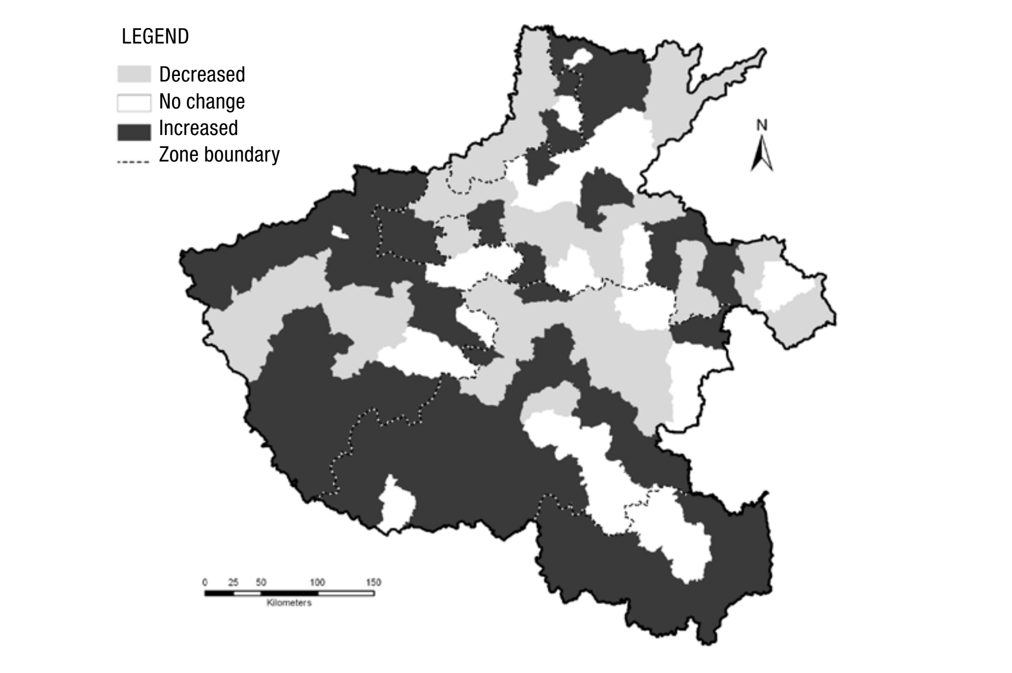
N = number of counties reporting.
Source: WorldFish-CAFS county survey in 2006.

2000. Overall, 47% of the counties reported higher fish prices, 31% reported lower, and the remaining 22% reported no change (Table 20). Market volatility expressed in changing prices may occur for different reasons, such as changes in demand for specific fish types, changes in the supplied quantity and quality of fish, and access to external markets, both domestic and international.

When analyzing the geographical distribution of counties that reported an increase in fish prices over the previous 5 years (Figure 18), we see increases in the areas with relatively low production. We do not have trends in the amounts of fish available from capture versus cultured fisheries over recent years, but one explanation could be a decrease in the capture of wild fish, causing the price to increase in areas where aquaculture production did not increase simultaneously to keep the total supply of fish stable. Another explanation could be growing demand for fish resulting from improved household income, creating a gap between demand and supply.

County fishery officers report that inadequate market access for fish farmers and imperfect market competition in the fishery sector was a common constraint on aquaculture producers.

Figure 18: Changes in fish price in Henan comparing 2005 prices against average prices of preceding 5 years by county



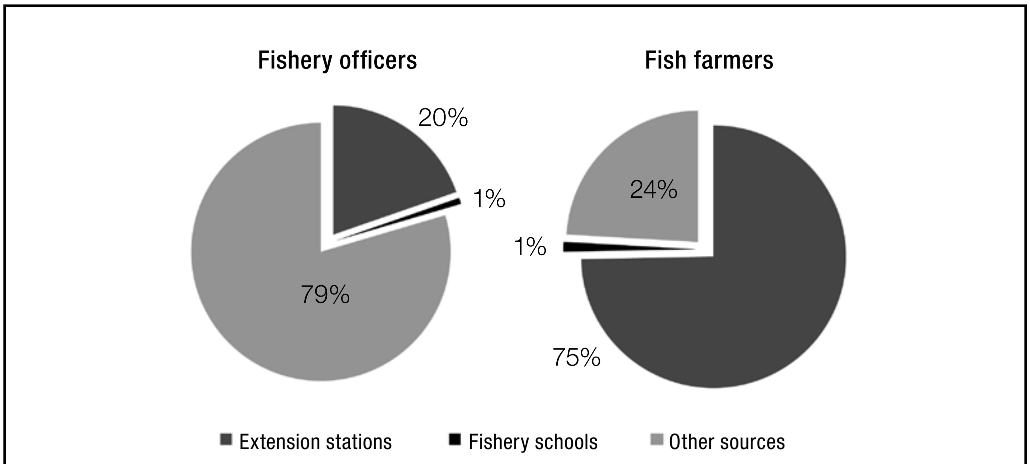
Source: WorldFish-CAFS county survey in 2006.

FISH FARMING-RELATED TRAINING

From 2003 to 2005, a total of 2,717 fishery officers in Henan Province received training in fish farming. The survey did not distinguish between initial and refresher training or consider the duration or intensity of the training. About 20% of the officers were trained at extension stations of the Bureau of Fisheries (Figure 19). In the same period, 144,170 fish farmers received training in fish farming. Again, the survey did not distinguish between initial or refresher training or consider the duration or intensity of the training. About 75% of the fish farmer trainees were trained at Bureau of Fisheries extension stations.

Finally, respondents were asked to provide a single rating on a scale of 1-4 (1=least to 4=most) of each county in terms of its level of experience with pond aquaculture. This

Figure 19: Sources of training for fishery officers and fish farmers in Henan



Source: WorldFish-CAFS county survey in 2006.

includes both the history of aquaculture production and the current level of production technology and information available. The findings, presented in Table 21, indicate that the level of experience in the province is rather high overall but with distinct differences among the four aquaculture zones. While Zones 1 and 4 have fewer counties with much experience in aquaculture, experience in Zone 2 and particularly in Zone 3 was rated as high. This result indicates a favourable environment for pond aquaculture and possibly further adoption of this farm enterprise by new entrants.

3.3 CASE STUDY OF POND FISH FARMING IN HENAN

In addition to the county-level survey, a producer survey was conducted in two prefectures of Henan in 2006, covering the 2005 production cycle. The sampling and methodology was designed jointly by WorldFish and CAFS and implemented by staff of the Henan Bureau of Fisheries, with CAFS handling the data encoding and entering. To capture the differences in terms of farming system and intensity level of aquaculture production, households from two prefectures in different aquaculture zones were included. The prefectures were (1) Zhengzhou, in northern Henan, which is close to the Yellow River, has good access to major market in Zhengzhou city (the provincial capital), and practises high-intensity production, and (2) Xinyang, in southern Henan, which practises a more traditional, mainly rainfed, farming system with extensive pond aquaculture.

Figure 20 shows the location of the two survey sites, the four identified aquaculture zones and the extent of urban centres in Henan. In addition to fish farmers, a control group of other farmers was included as respondents to allow comparison of household characteristics and thus determine what factors drive or hinder the adoption of pond aquaculture.

The total sample for the survey was 286 households (Table 22). In this section of the case study report, we have presented some of the findings of the household survey to provide a better understanding of local pond aquaculture in Henan.

PROFILE OF RESPONDENTS AND OF POND FISH FARMERS

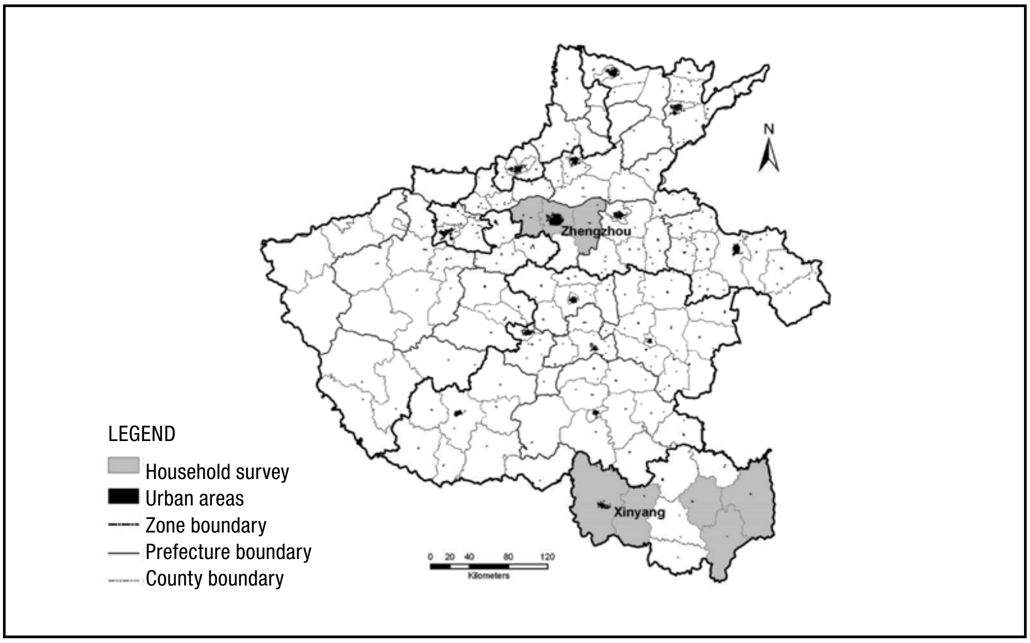
The descriptive statistics subsequently presented were derived from the household dataset to create a better understanding of the realities of pond fish farming in the study area. Figures have been presented separately for fish famers and the control group and disaggregated by geographical region to account for differences in infrastructure and the varying intensity of production. We conducted two series of t-tests for all the major variables to check for differences in means of subsamples. The first series of t-tests was run between the Xinyang and Zhengzhou subsamples, with results indicated in the variable row “All” behind the subsample means. The letters a and b indicate statistically significant differences in sample means. (Table 23) The second series of t-tests was conducted between subgroups of fish farmers and other farmers, with results indicated in the

Table 21: Pond aquaculture experience in counties in Henan by aquaculture zone, 2005

Experience of county in pond aquaculture (on a scale of 1-4)	Aquaculture zone (%)				All (N = 126)
	Zone 1 (N = 33)	Zone 2 (N = 44)	Zone 3 (N = 9)	Zone 4 (N = 40)	
Least experienced (1)	39.4	0.0	0.0	2.5	11.1
Somewhat experienced (2)	30.3	13.6	0.0	40.0	25.4
Moderately experienced (3)	24.2	50.0	11.1	45.0	38.9
Most experienced (4)	6.1	36.4	88.9	12.5	24.6
Total	100.0	100.0	100.0	100.0	100.0

N = number of counties reporting.
Source: WorldFish-CAFS county survey in 2006.

Figure 20: Henan, showing urban centres and sites for the household survey in two prefectures



Source: Provided by CAFS for the RD project, the WorldFish Center.

Table 22: Sample size for the 2006 household survey in Henan by prefecture

	Xinyang	Zhengzhou	All
Total sample size	150	136	286
Fish farmers	100	91	191
Other farmers	50	45	95

column "All" behind subsample means. In this case, the letters c and d indicate statistically significant differences between sample means.

The household size was on average 3.3 members for the whole sample, and there was no significant difference between fish farmers and other farmers. Meanwhile the household size was significantly larger in Zhengzhou than in Xinyang. The average farm size for the total sample was around 1.5 ha including ponds and cropland, with marked differences both between the two regions and between fish farmers and other farmers (Table 23). Farms were significantly larger in the relatively commercial Zhengzhou, and fish farmers had larger farms than other farmers. In Xinyang, in the south, fish farms were on average three times larger than other farms, and in Zhengzhou the average fish farm was six times larger than other farms. In line with this finding, it was common for fish farmers to rent or lease additional area.

In our sample, 15% of all fish farmers, and 22% in Xinyang, rented land in the period covered by the survey. The average size of rented-in land was 0.7 ha, almost half of the total farm size. At the same time, 10% of the other farmers, most of them in Zhengzhou, rented out land averaging 0.4 ha.

With regard to the income of farm households, there was no significant difference between the regions, with average annual total household incomes of RMB18,912 ($2,773) in Xinyang and RMB22,637 ($3,319) in Zhengzhou (Table 24).

As the average household was larger in Zhengzhou, the average annual per capita income of $907 was lower than the $946 reported for Xinyang, despite farms being larger in Zhengzhou. Household income was significantly higher for fish farmers than for other farmers. In both surveyed prefectures, the average household income of fish farmers was almost double

Table 23: Demographics of survey respondents in Henan by prefecture

Variable	Xinyang		Zhengzhou		All	
Household size (individuals)						
All	2.93	(1.14) [a]	3.66	(1.12) [b]	3.28	(1.19)
Fish farmer	3.02	(1.20)	3.53	(1.11)	3.26	(1.18) [c]
Other farmer	2.76	(0.98)	3.91	(1.10)	3.31	(1.19) [c]
Farm size (ha)						
All	1.22	(1.43) [a]	1.72	(2.33) [b]	1.46	(1.93)
Fish farmer	1.54	(1.62)	2.38	(2.61)	1.94	(2.18) [c]
Other farmer	0.49	(0.39)	0.38	(0.20)	0.44	(0.32) [d]
Leasing of farm land						
Lease in (%)						
Fish farmer	22.0		7.7		15.2	
Other farmer	2.0		0.0		1.1	
Lease out (%)						
Fish farmer	0.0		0.0		0.0	
Other farmer	6.0		13.3		9.5	
Fish farmers lease in (ha)	0.82	(0.96)	0.42	(0.30)	0.72	(0.85)
Other farmers lease out (ha)	0.51	(0.10)	0.29	(0.08)	0.36	(0.14)

ha = hectare.
Note: Figures in parentheses are standard deviations, and the superscripts a, b, c and d indicate statistically significant differences in subsample means. T-tests were conducted between subsamples of the two regions and between fish farmers and other farmers.
Source: WorldFish-CAFS household survey in 2006.

Table 24: Total income and share of different income sources in Henan by prefecture

Variable	Xinyang		Zhengzhou		All	
Household income (RMB/year)						
All	18,912 [a]	(19,779)	22,637 [a]	(32,526)	20,367	(26,460)
Fish farmers	22,079	(22,985)	26,047	(37,709)	24,482 [c]	(30,995)
Other farmers	12,580	(7,802)	13,731	(13,513)	13,125 [d]	(10,841)
Exclusive fish farmers (number)	8		15		23	
Fish farmer household income (%)						
On-farm income	77	(25)	82	(68)	80	(50)
Crop farming	10	(11)	22	(39)	16	(28)
Livestock	8	(19)	1	(5)	4	(14)
Fish farming	59	(27)	59	(76)	59	(55)
Off-farm income	23	(25)	18	(68)	20	(50)
Other farmer household income (%)						
On-farm income	49	(29)	32	(30)	41	(30)
Crop farming	40	(24)	30	(28)	35	(26)
Livestock	9	(9)	3	(9)	6	(9)
Off-farm income	51	(29)	68	(30)	59	(30)

RMB = renminbi.
Note: Figures in parentheses are standard deviations, and the superscripts a, b, c and d indicate statistically significant differences in subsample means. T-tests were conducted between subsamples of the two regions and between fish farmers and other farmers. The fish farmer category includes exclusive fish farmers and fish farmers with other income sources.
Source: WorldFish-CAFS household survey in 2006.

the reported income of other farmers. For all subsamples, the variability of the income figures is very high, indicating huge differences among households even within subsamples. The income figures reported here are higher than the averages reported in Table 11 partly because data sources were different — government statistics versus the household survey — but also because the survey included in the sample a much higher proportion of fish farmers, who have much higher average income than other farmers.

When considering the shares of different income-earning activities in total household income, we find that the income generated on fish farms is 77% in Xinyang and 82% in Zhengzhou, occupying a much higher proportion than off-farm income. Most of this on-farm income was from the fish farming, with terrestrial crops and livestock much less important. Overall, fish farmers derived 59% of their total household income from fish farming (Table 24). Other farming households ventured to a larger degree into off-farm activities, which made up 51% of total household income in Xinyang and 68% in Zhengzhou. Income from fish farming was high, leaving fish-farming households better off than others. Fourteen respondents in Zhengzhou reported losses from fish farming during the survey period, but none of the respondents in Xinyang did. Assuming that the income figures are correct, this indicates the risk of intensive, commercial fish farming. Losses have been included in the averages reported in Table 24. A small share of farmers, 16% in Zhengzhou and 8% in Xinyang, specialized entirely on fish farming, with no other sources of income.

FRESHWATER POND AQUACULTURE PRODUCTION

As stated above, freshwater pond culture of finfish is the most common form of aquaculture in Henan. The farmers interviewed for the household survey had on average 2.5 ponds with a total pond area of 1.5 ha (Table 25). There were, however, marked differences between the two survey areas, with respondents in Zhengzhou having a significantly larger number of ponds and total pond area than farmers in Xinyang. Ponds operated by surveyed fish farmers were on average 1.7 metres deep. The pond depth was 35 centimetres deeper for Xinyang fish farmers. This can be explained by their high dependence on rainfall, as reported by 39% of respondents, as greater pond depth allows storing more rainwater for subsequent dryer periods. Irrigation is common in Zhengzhou, drawn from either the low groundwater table, as reported by 76% of respondents there, or rivers, as reported by 24%. Only 10% of respondents in Xinyang used groundwater and only 15% sourced water from rivers.

There was no significant difference between the two areas in the average length of experience farmers had in raising fish, but the share of recent adopters with less than 5 years' experience was larger in Xinyang, at 39%, than in Zhengzhou, at 26%. At

Table 25: Key characteristics of fish farming in Henan by prefecture

Variable	Xinyang	Zhengzhou	All
Number of ponds	1.51 (1.13) [a]	3.49 (4.69) [b]	2.46 (3.48)
Total pond area (ha)	1.23 (1.30) [a]	1.80 (1.96) [b]	1.50 (1.67)
Pond depths (m)	1.91 (0.50) [a]	1.56 (0.19) [b]	1.74 (0.42)
Fish farming experience (years)	8.41 (5.96) [a]	9.27 (5.19) [a]	8.82 (5.61)
Total yield (t/ha)	3.81 (2.39) [a]	16.48 (5.53) [b]	9.90 (7.60)
Stocking density ('000/ha)	5.39 (3.68) [a]	21.70 (6.76) [b]	13.22 (9.78)

ha = hectare, m = metre, t = tonne.
Note: Figures in parentheses are standard deviations. The superscripts a and b indicate statistically significant differences in subsample means (t-tests were conducted between regional subsamples).
Source: WorldFish-CAFS household survey in 2006.

the same time, some respondents in both regions had given up fish farming for various reasons (they are counted as “other farmers”). The number of former fish farmers was 10 in Zhengzhou, or 22% of the other farmers in the Zhengzhou sample, and 3 in Xinyang, or 6%.

The difference in the yield per hectare between the two regions was very large, with fish farmers in Xinyang harvesting on average 3.8 t/ha, while farmers in Zhengzhou realized average fish yields of 16.5 t/ha. This big difference in yield can be explained by the considerable difference in production intensity, especially higher use of inputs. The difference in the water source mentioned above indicates that a more regular and reliable supply from sources such as groundwater and rivers was common in Zhengzhou. The use of other major inputs to pond aquaculture is shown in Table 26.

A major variable production input in fish farming is the number of fry or fingerlings stocked. Our survey found stocking rates some four times higher in Zhengzhou than in Xinyang. While the dominant species combination in both regions was polyculture of carps, there were considerable differences with regard to the share of different carps raised. In Zhengzhou, almost all ponds were stocked mostly with common carp, followed by grass carp. In Xinyang, the dominant species were crucian and silver carp. Only four fish farmers — all in the Zhengzhou sample — specialized in culturing species other than carps.

In Zhengzhou, the more intensive and commercial production area, the major input for freshwater pond production besides seed was commercial feed (Table 26). While commercial feed was used by all 55 fish farmers who reported production information in this area, only one out of the

Table 26: Input use and input costs of fish farming in Henan by prefecture

Type of input	Xinyang (N = 91)		Zhengzhou (N = 55)	
Commercial feed				
Frequency (number farmers)	1		55	
Amount (t/ha)	1.88	(na)	14.60	(4.96)
Cost (RMB/ha)	4,500	(na)	85,788	(30,326)
Fertilizer				
Frequency (% farmers)	19		0	
Amount (t/ha)	1.34	(0.94)	0	
Cost (RMB/ha)	1,272	(972)	0	
Grass				
Frequency (% farmers)	42		0	
Amount (t/ha)	5.46	(8.54)	0	
Cost (RMB/ha)	1,069	(2,480)	0	
Manure				
Frequency (% farmers)	75		1	
Amount (t/ha)	15.43	(14.94)	3.75	(na)
Cost (RMB/ha)	1,684	(1,537)	563	(na)
Oil cake				
Frequency (% farmers)	25		0	
Amount (t/ha)	1.49	(1.52)	0	
Cost (RMB/ha)	3,567	(3,643)	0	
Rice bran				
Frequency (% farmers)	20		0	
Amount (t/ha)	2.87	(1.78)	0	
Cost (RMB/ha)	7,161	(4,496)	0	

ha = hectare, N = number of sampled households reporting inputs, na = not available, RMB = renminbi, t = tonne.
Note: Figures in parentheses are standard deviations.
Source: WorldFish-CAFS household survey in 2006.

91 respondents who reported production information in Xinyang used commercial feed.

Instead of commercial feed, fish farmers in Xinyang used inputs such as fertilizer or manure to foster the growth of algae in the pond as natural food or supplied as direct feed grass, oil cake and rice bran. The number of farmers who applied these different inputs, the average amount used and the costs are listed in Table 26. The amounts of these inputs varied widely, as indicated by the high standard variations. This is because the inputs can be substituted for one another, and different farmers use different combinations of fertilizer or feeds.

Farmers reported significant costs for pesticides used in aquaculture to either prevent or control fish diseases or for general pond hygiene. In Zhengzhou, the average expenditure on pesticides amounted to RMB4,126 ($605) per hectare of pond, while costs were significantly lower in Xinyang, averaging RMB658 ($96).

When analyzing the performance of pond aquaculture in Henan we found that, overall, fish production is more lucrative in Xinyang, with net returns of RMB10,770 ($1,579) per hectare, disregarding fixed costs. As described above, production intensity and the use of inputs is much higher in Zhengzhou, which is reflected in the much higher variable cost (Table 27). The yield realized under this higher intensity is around four times higher, but this higher income opportunity comes at the cost of much higher risk. A significant number of farmers, 14% in Xinyang and 44% in Zhengzhou, reported costs higher than income. When excluding those farmers from the analysis, realized net revenues were as high as RMB14,167 ($2,077) per hectare in Xinyang and RMB29,099 ($4,267) in Zhengzhou.

In line with the differences in the two farming systems and intensity levels described above, it comes as no surprise that the size of fish at the time of harvest is different for the two regions as well (Table 28). The more intensive production practices, including the application of large amounts of commercial feed, go hand-in-hand with larger fish sizes at harvest for most species. At the same time, the market prices realized by the fish farmers in the two different regions varied by species, reflecting the general supply-and-demand situation for different species in the two areas. For example, the high price for common carp in Zhengzhou reflected the high demand for this species in this market and explains why most farmers opt to culture it. In Xinyang, the price for silver carp was much higher than in Zhengzhou.

Table 27: Performance indicators of fish farming in Henan by prefecture

Variable	Xinyang (N = 91)		Zhengzhou (N = 55)	
Total variable cost (TVC) (RMB/ha)	14,387	(11,076) [a]	99,713	(31,492) [b]
Costs of feed (% of TVC)	13.3	(19.7)	84.9	(7.8)
Cost of seed (% of TVC)	54.7	(26.5)	0.6	(0.5)
Operating cost (% of TVC)	6.8	(8.3)	8.8	(5.4)
Other costs (% of TVC)	25.2	(18.1)	5.6	(3.1)
Yield (kg/ha)	3,823	(2,421) [a]	16,832	(4,591) [b]
Gross return (RMB/ha)	25,156	(19,144) [a]	103,245	(30,063) [b]
Net return (RMB/ha)	10,770	(15,478) [a]	3,533	(37,975) [a]
Per unit production costs (RMB/kg)	4.3	(3.9) [a]	6.1	(1.9) [b]
Benefit/cost ratio	2.19	(1.34) [a]	1.13	(0.5) [b]

ha = hectare, kg = kilogram, N = number of sampled households, RMB = renminbi
Notes: Figures in parentheses are standard deviations. The superscripts a and b indicate statistically significant differences in subsample means (t-tests were conducted between regional subsamples). As estimates include only those farmers for whom full production information was available, the yield figures used to generate the gross return for this table vary slightly from results in Table 25. The net return is computed by deducting total variable costs from the gross return, without considering fixed costs. The benefit/cost ratio is the gross return divided by the total variable costs.

Source: WorldFish-CAFS household survey in 2006.

Table 28: Harvested size and market price of fish in Henan by prefecture

Variable	Xinyang	Zhengzhou	All
Size at harvest (fish number/kg)			
Bighead carp	3.47 (0.91) [a]	1.36 (0.17) [b]	2.84 (1.24)
Common carp	1.37 (1.37) [a]	1.66 (0.32) [b]	1.57 (0.38)
Crucian carp	0.56 (0.56) [a]	0.62 (0.16) [a]	0.58 (0.41)
Grass carp	3.59 (0.68) [a]	2.62 (0.53) [b]	3.30 (0.77)
Silver carp	2.73 (1.03) [a]	1.52 (0.11) [b]	2.42 (1.03)
Other fish	1.04 (0.39) [a]	1.42 (0.57) [b]	1.31 (0.54)
Market price (RMB/kg)			
Bighead carp	6.68 (1.62) [a]	3.96 (0.18) [b]	5.87 (1.85)
Common carp	4.69 (0.94) [a]	6.02 (0.66) [b]	5.63 (0.96)
Crucian carp	8.60 (2.29) [a]	9.54 (0.77) [b]	8.90 (1.98)
Grass carp	7.11 (1.83) [a]	9.03 (0.37) [b]	7.69 (1.77)
Silver carp	5.72 (1.57) [a]	3.02 (0.19) [b]	5.05 (1.80)
Other fish	9.47 (4.71) [a]	11.90 (1.30) [b]	11.18 (2.95)

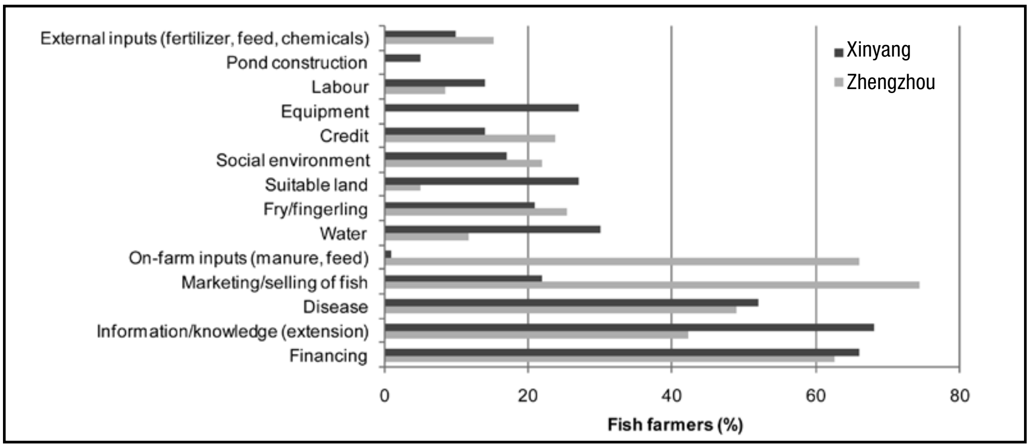
kg = kilogram, RMB = renminbi.
Note: Figures in parentheses are standard deviations. The superscripts a and b indicate statistically significant differences in subsample means (t-tests were conducted between regional sub-samples).

Source: WorldFish-CAFS household survey in 2006.

Larger sizes and higher prices in the “other fish” category could be a result of different species included in this category in both regions, with higher-priced products produced in Zhengzhou than in Xinyang.

Fish farmers in the two regions identified very different problems (Figure 21). In Zhengzhou, the top three problems related to the marketing and selling fish (identified by 74% of respondents), lacking or limited on-farm inputs for feeding fish or manuring ponds (66%), and the unavailability of or poor access to financing (63%). These problems are in line with the intensive production, local competition, and the large amount of capital needed to pay in advance for external inputs, mainly commercial feed. In Xinyang, on the other hand, the top three problems fish farmers faced were a perceived lack of information and knowledge or access to extension services (identified by 68% of respondents), the unavailability of or poor access to financing (66%), and disease (52%). The last two problems were major concerns to fish farmers in Zhengzhou as well. Other problems, such as limited access to water or the unavailability of

Figure 21: Major problems reported by fish farmers in the two prefectures



Source: WorldFish-CAFS household survey in 2006.

equipment and suitable land in a generally hilly environment, were specific to the situation in the south of Henan.

With regard to the extent and sources of aquaculture extension, respondents in Xinyang reported a larger number of interactions with the resource staff of nongovernmental organizations, while fish farmers in Zhengzhou had better access to government extension staff, other aquaculture experts and other resource people. The average number of household members who had received aquaculture-related training was 1.44 in Zhengzhou and 1.10 in Xinyang.

An important impact of fish farming is usually improved diet and nutrition in fish-producing households. We compared fish consumption and purchases both by region and by farm type. The results show that fish consumption was higher in terms of both frequency and absolute amounts among fish-farming households (Table 29). At the same time, fish farmers purchase less fish, and fish of lower value, than do other farmers.

There is a significant difference in consumption patterns between the two regions, with respondents in Xinyang reporting higher fish consumption than in Zhengzhou. This could be either the result of a longer tradition of fish farming and a cultural preference for fish in this region as indicated by Henan authorities or an indicator of the price of fish as a source of protein relative to others. Lower economic development in the southern region may also be a factor in the evident higher preference for fish, as fish is a relatively cheap source of animal protein. More detailed analysis and additional information on the prices of different types of animal protein are required to validate these hypotheses.

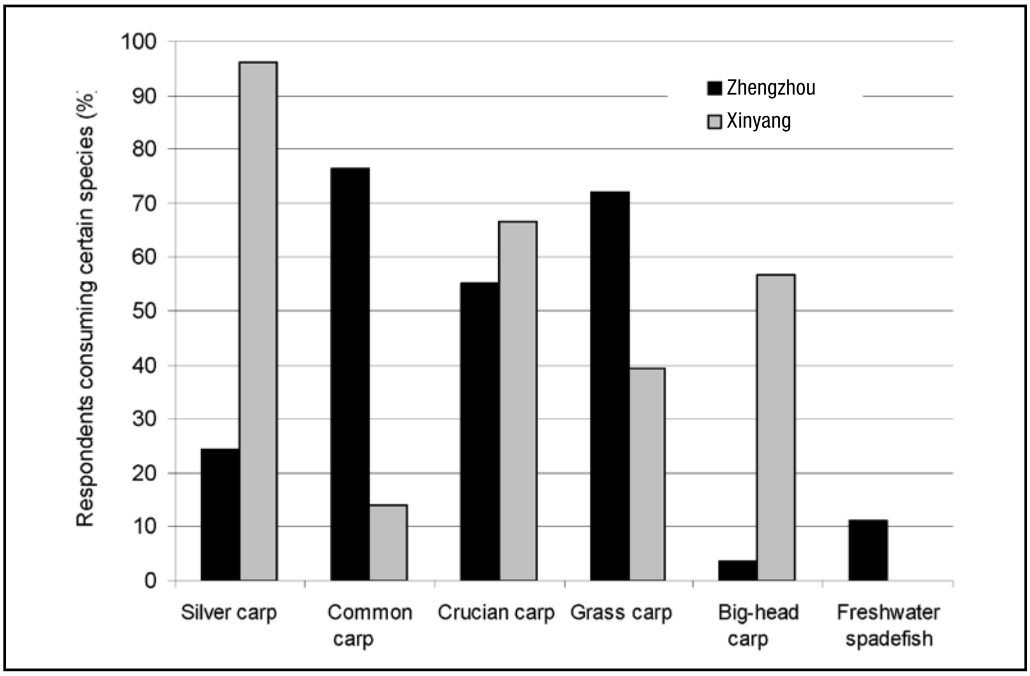
The share of households that have consumed a certain fish species is an indicator of preference, availability and relative prices.

Table 29: Fish consumption of households in Henan by prefecture

Variable	Xinyang (N = 150)		Zhengzhou (N = 127)		All (N = 277)	
Fish consumption (times/month)	**5.22**	**(3.80)** [a]	**3.69**	**(2.78)** [b]	**4.52**	**(3.45)**
Fish farmers	6.24	(4.23)	4.02	(3.07)	5.24	(3.90) [c]
Other farmers	3.18	(1.19)	3.09	(2.05)	3.14	(1.65) [d]
Fish consumption (kg/HH/month)	**16.6**	**(12.9)** [a]	**12.0**	**(10.7)** [b]	**14.5**	**(12.1)**
Fish farmers	19.5	(14.3)	13.9	(12.4)	16.95	(13.7) [c]
Other farmers	10.9	(6.3)	8.5	(5.4)	9.77	(6.0) [d]
HHs purchasing fish (number)	76		59		135	
Fish farmers	26		19		45	
Other farmers	50		40		90	
Purchasing fish (kg/HH/year)	**131.1**	**(97.0)** [a]	**52.1**	**(48.1)** [b]	**96.6**	**(88.4)**
Fish farmers	102.3	(103.9)	28.1	(23.0)	70.96	(87.9) [c]
Other farmers	146.0	(90.8)	63.5	(52.7)	109.34	(86.3) [d]
Purchased fish price (RMB/kg)	**2.63**	**(0.36)** [a]	**3.75**	**(0.50)** [b]	**3.12**	**(0.70)**
Fish farmers	2.47	(0.33)	3.62	(0.57)	2.96	(0.72) [c]
Other farmers	2.70	(0.35)	3.81	(0.46)	3.20	(0.68) [d]

HH = household, kg = kilogram, N = number of households sampled, RMB = renminbi.
Note: Figures in parentheses are standard deviations. The superscripts a, b, c and d indicate statistically significant differences in subsample means (t-tests were conducted between subsamples of the two regions and between fish farmers and other farmers).
Source: WorldFish-CAFS household survey in 2006.

Figure 22: Share of major fish species consumed at household level by prefecture



Note: Only species mentioned by 10% or more of respondents in an area have been included.
Source: WorldFish-CAS household survey in 2006.

The popularity of different fish species varied between the two regions (Figure 22). The consumption picture reflects the major cultivated species in each of the regions, with common carp popular in Zhengzhou and silver carp popular in Xinyang.

FACTORS DETERMINING ADOPTION OF FRESHWATER POND AQUACULTURE

Finally, we tried to determine the factors that drive the adoption of freshwater pond aquaculture in Henan. We used a logit model with a dependent variable equal to one if the household produces fish and zero otherwise. As the production systems are so different in the two regions, we opted to run two separate regressions for Zhengzhou and Xinyang on the rationale that the determining factors for adoption in a commercial aquaculture enterprise can be expected to be very different from the driving forces of adopting integrated, subsistence-oriented aquaculture.

The explanatory variables we included are standard farm and farmer characteristics such as the educational level of the household head (included in the form of two dummy variables), farmer's age, farm area, whether or not the household raises animals (dummy one if household raises animals, zero otherwise) and the number of household members. Adoption theory holds that better-educated, larger households are more likely to be among the innovators adopting a profitable new technology. The results of our econometric analysis are presented in Table 30.

In the case of Zhengzhou, we found that fish farmers achieved significantly higher education, are slightly older and operate larger farms, though this last factor may be more a result of fish farming more than a precondition, as the land is rented in.

Aquaculture adopters are less likely to raise animals and have smaller households in both regions. In addition to the adoption model, we constructed a second model that distinguishes between high-intensity producers who realize per-hectare yields with standard deviations of 0.5 or more above the average yield for their respective region. This is relevant to knowing what preconditions are required for a farmer to do very well with the fish-farming enterprise. The results are not very conclusive for Zhengzhou, where only the household size was significant (Table 31). This could partly be because all famers in this area operate at a highly commercial level and thus factors other than the included variables determine success. For Xinyang, higher-educated farmers who raise animals but have smaller farms realize higher yields. This can be explained with the higher integration of aquaculture into the farming system, which requires the use of manure acquired on the farm and is labour and knowledge intensive to operate.

Table 30: Factors determining the adoption of pond aquaculture in Henan

	Zhengzhou			Xinyang		
	Coefficient		s.e.	Coefficient		s.e.
Constant	-7.55	**	3.13	1.21		2.14
Education dummy (junior high school)	2.57	**	1.24	0.04		0.59
Education dummy (senior high school)	2.84	*	1.49	-0.02		0.78
Age of household head (years)	0.10	*	0.05	-0.02		0.03
Total farm area (ha)	8.47	***	1.86	3.48	***	0.80
Animal raiser dummy	-2.41	**	1.03	-1.84	***	0.56
Household size (number of people)	-0.88	**	0.41	-0.32		0.25
Log likelihood	-29.04			-63.40		

ha = hectare, s.e. = standard error .
Note: The dependent variable for logit regression is the dummy for fish farmer (1) versus other farmer (0). * denotes statistical significance at $\alpha = 0.1$, ** at $\alpha = 0.05$ and *** at $\alpha = 0.01$.

Table 31: Factors determining intensification of pond aquaculture in Henan

	Zhengzhou			Xinyang		
	Coefficient		s.e.	Coefficient		s.e.
Constant	0.46		1.26	-1.86		1.61
Education dummy (junior high school)	-0.60		0.49	-0.44		0.50
Education dummy (senior high school)	-0.10		0.60	1.84	**	0.74
Age of household head (years)	-0.02		0.02	0.04		0.02
Total farm area (ha)	0.06		0.10	-0.47	**	0.20
Animal raiser dummy	-0.36		0.55	1.06	**	0.45
Household size (number of people)	0.29	*	0.17	0.04		0.19
Credit dummy	-0.32		0.61	-1.26	*	0.67
Log likelihood	-89.53			-82.8		

ha = hectare, s.e. = standard error.
Note: The dependent variable for logit regression is the dummy for intensive production (0.5 standard deviation above the mean yield (1) and otherwise (0). * denotes statistical significance at $\alpha = 0.1$, ** at $\alpha = 0.05$ and *** at $\alpha = 0.01$.

4. CONSTRAINTS AND OPPORTUNITIES FOR AQUACULTURE IN CHINA

The review of the development and status of aquaculture nationally in chapter 2 and the case study of Henan Province reported in chapter 3 touched on the impressive past development of pond aquaculture in China and the great opportunities and potential constraints for further development. In this final chapter, we highlight and discuss some crucial issues that need to be addressed for aquaculture to realize its full potential. Having described great variability within the sector in this study, we understand that different aspects apply to certain geographic areas or types of production systems to varying degrees.

Some of the issues imposing constraints on aquaculture development are internal to the sector in a sense that they are either created or aggravated by aquaculture activities. One major problem in this category is the build-up and spread of diseases related to production intensification (Yang 2005). While this is of little or no concern to traditional extensive polyculture systems, higher stocking density and intensification multiply the risk of production losses from diseases. Li (2003) states that yield losses from aquatic diseases in China are estimated to be as high as 15-20% of the total production, worth some $1 billion per year. Potential solutions are, for example, improved management practices for higher-intensity production and good choices when determining the intensity of aquaculture production. National research emphasizes improving the diagnosis and early prediction of aquatic diseases and the development of disease control strategies that avoid applying antibiotics.

The aquaculture export subsector in particular faces issues of food safety and quality control. Currently, chemicals and medications that may pose hazards to human and environmental health and have been banned in many importing countries are still widely used in intensive aquaculture in China. This has caused shipments of finfish and other seafood originating in China to be rejected, damaging the reputation and image of Chinese aquatic products abroad. This problem is not confined to aquaculture but applies to the wider agricultural sector and even manufactured products such as toys originating in China. With the recent food scandals in China regarding, for example, melamine in milk and other products, and with the increasing awareness of domestic consumers, it has become clear that changes in the official approach to food safety are inevitable and require a policy response such as bans on certain chemicals, better enforcement of existing regulations and improved quality control. This will become increasingly important as local consumers gain better access to information through, for example, the Internet.

Similarly, the lack of human resource capacity both among producers and in the public extension system is commonly perceived as a constraint to further aquaculture development (FAO 1997). This, too, is not unique to aquaculture but a general problem of the entire primary sector in China, as well as in many other developing and transitional countries. Leading agricultural economists, especially from the Center for Chinese Agricultural Policy, a major national think tank, have repeatedly argued for reforming the public extension system.

Another frequently listed constraint on further aquaculture development and increased productivity is the lack of readily available, high-quality fish seed. Though notable progress has been achieved in terms of artificial propagation for the major species, seed is not always available, especially in more remote rural areas, and testing to certify disease-free seed is not compulsory for all hatcheries. This leaves much of the risk with producers, who have little means of assessing the quality of the seed beforehand and thus have to trust the hatchery or nursery.

Though external inputs such as commercial feed are widely available in China, there are concerns about the testing of feed quality and ample anecdotal evidence of toxic chemicals in aquatic feeds poisoning fish. Even more important, it is highly unsustainable to use trash fish in aquaculture feed. Given the size of the aquaculture subsector in China and the stagnating or declining state of global capture fisheries, alternatives will be in high demand. In 2004, the Chinese aquaculture industry used 5 million t of soybean as fish feed (Agri-Food Trade Service 2005).

In addition to the subsector's inherent constraints, a number of other issues arise primarily from other causes. One very significant constraint is environmental degradation, most prominently in the quality of water. Intensive aquaculture production contributes to water pollution mainly in the form of toxic waste products originating from intensive systems (FAO 1997).

A constraint that is truly external to aquaculture is the scarcity of the two most important resources required for aquaculture production: land and water. China feeds 22% of the global population with only 9% of global arable land and 27% of global freshwater resources. The country now accounts for 67% of global aquaculture production. There are competing use options for both land and water, and both resources are becoming increasingly scarce in China. Restrictions now limit the conversion of arable land for aquaculture production, and options to further expand the pond production area are constrained. This makes essential the development of culture systems that conserve land and water and produce few wastes. Also needed are environmental impact assessments, protocols and guidelines for aquaculture zoning and the enforcement of higher environmental standards. This is particularly important as meeting demand from a growing and more prosperous population will require increased aquaculture production and a shift toward high-value products. Since options for further expanding aquaculture area are very limited, additional production will have to come from intensified production supported by scientific and technological development mainly in the areas of selective breeding, nutritional improvement, and refined farm management for more sustainable and environmentally friendly aquaculture production (Li 2003).

The potential of freshwater aquaculture in China is doubtless enormous, considering the anticipated increase in local demand and improved access to international markets achieved with WTO accession. Fish and aquatic products can be produced more efficiently than most other sources of animal protein with regard to the consumption of water, land and energy. China has a strong domestic research system for aquaculture that can draw on past achievements in breeding, hatchery technology and improved systems management. If constraints can be adequately addressed, aquaculture is likely to grow further and become even more important. However, national decision makers face formidable challenges regarding such issues as assured land tenure to encourage private investment, improved access to water and credit, strengthened legislation, stricter monitoring of product quality and safety, and the adoption of more environmentally sound production practices.

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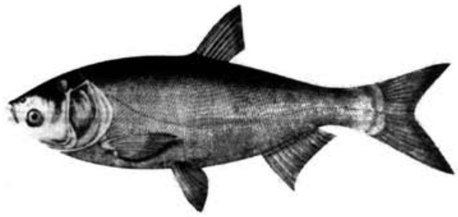
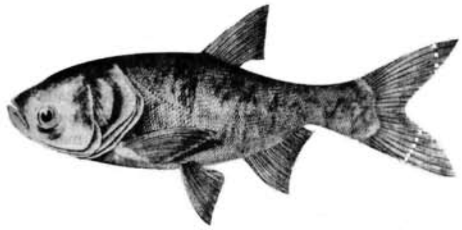
ANNEXES

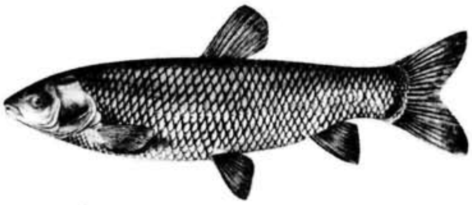
Annex 1: Major fish species cultured in China



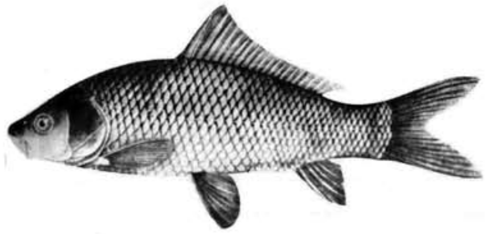
a. Silver carp
(Hypophthalmichthys molitrix)



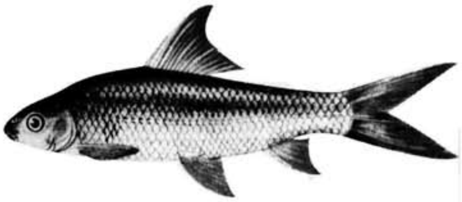
b. Bighead carp carp
(Aristichthys nobilis)



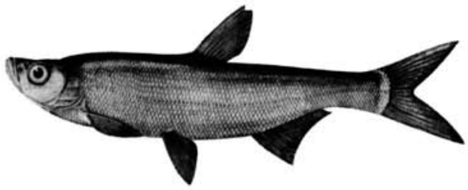
c. Grass carp
(Ctenopharyngodon idellus)



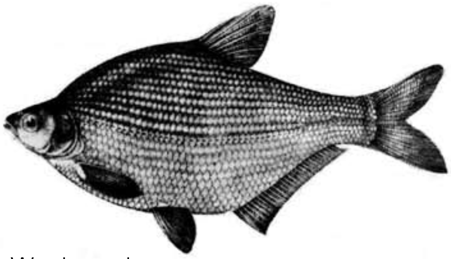
d. Common carp
(Cyprinus carpio)



e. Mud carp
(Cirrhina molitorella)



f. Top mouth
(Erythroculter ilishaeformis)



g. Wuchang bream
(Megalobrama amblycephala)

h. Mandarin fish
(Siniperca chuatsi)

i. Catfish
(Parasilurus asotus)

j. Snakehead
(Ophiocephalus argus)

Source: Li and Xu 1995.

Annex 2: English and scientific names of major fish species cultured in China

English name	Scientific name
Bighead carp	*Aristichthys nobilis*
Black bream	*Megalobrama terminalis*
Black carp	*Mylopharyngodon piceus*
Channel catfish	*Ictalurus puntatus*
Common carp	*Cyprinus carpio*
Crucian carp	*Carassius auratus*
Freshwater spadefish	*Colossoma brachypomum*
Freshwater yellowtail	*Xenocypris davidi*
Grass carp	*Ctenopharyngodon idellus*
Guangdong bream	*Megalobrama hoffmanni*
Japanese eel	*Anguilla japonica*
Loach	*Misgurnus anguillicaudatus*
Longbarbel catfish	*Mystus guttatus*
Mandarin fish	*Siniperca chuatsi*
Mud carp	*Cirrhina molitorella*
Predatory carp	*Chanodichthys erythropterus*
Silver carp	*Hypophthalmichthys molitrix*
Snakehead	*Ophiocephalus argus*
Tilapia	*Oreochromus niloticus*
Top mouth	*Erythroculter ilishaeformis*
White Amur bream	*Parabrama pekinensis*
Whitespotted catfish	*Clarias fuscus*
Wuchang (or blunt snout) bream	*Megalobrama amblycephala*

Annex 3: Output of aquatic products in China by environment (in 10,000 t)

Year	Total aquatic production	Marine			Freshwater		
		Capture	Cultured	Total	Capture	Cultured	Total
1950	91.1	53.6	1.0	**54.6**	29.9	6.6	**36.5**
1955	251.8	154.9	10.7	**165.6**	54.3	31.9	**86.2**
1960	303.8	174.9	12.1	**187.0**	66.9	49.9	**116.8**
1965	298.4	191.0	10.4	**201.4**	45.6	51.4	**97.0**
1970	318.5	209.7	18.4	**228.1**	32.2	58.2	**90.4**
1975	441.2	306.3	27.9	**334.2**	31.2	75.3	**106.5**
1980	449.7	281.3	44.4	**325.7**	33.9	90.2	**124.0**
1985	705.2	348.5	71.2	**419.7**	47.6	237.8	**285.4**
1990	1,237.0	550.9	162.4	**712.4**	78.3	445.4	**523.7**
1995	2,517.2	1,026.8	412.3	**1,439.1**	137.3	940.8	**1,078.1**
2000	4,278.5	1,477.5	1,061.3	**2,538.8**	226.4	1,513.4	**1,739.7**
2005	5,107.6	1,453.5	1,384.8	**2,838.3**	258.8	2,010.5	**2,269.3**
2006	5,290.4	1,442.0	1,445.6	**2,887.6**	254.4	2,148.3	**2,402.7**

t = tonne.
Source: NBSC 2007.

Annex 4: Summary of the stages reached in artificial reproduction and nursing of cultured freshwater species

Groups	No. of species	Artificial propagation level			Nursing level		
		Complete[a]	Half[b]	Pending	Large scale[c]	Small scale[d]	Pending
Finfish	59	45	8	6	38	15	5
Crab, prawn	3	3			3		
Mollusc	2	2			2		
Turtle	1	1			1		

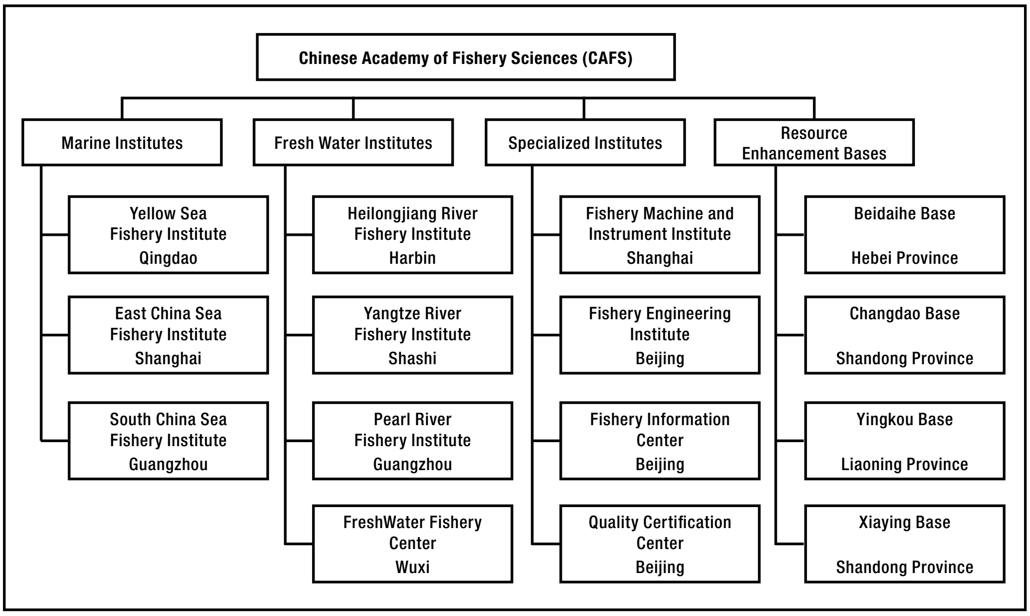
[a] Whole life cycle can be controlled artificially.
[b] Brooders are collected from the wild.
[c] Production volume can be managed to provide as many as needed.
[d] Production volume is technically restricted.
Source: Adapted from Li 2003.

Annex 5: Average yield of different types of aquaculture in China, 1980-2000 (in kg/ha)

Types	1980	1985	1990	1995	2000	1980-2000 fold increase
Freshwater						
Pond	765	1,395	2,385	3,742	4,899	6.4
Lake	150	256	435	710	1,043	6.9
Reservoir	90	150	435	538	922	10.2
Channel	345	525	795	1,337	1,756	5.1
Paddy				265	487	
Brackish/marine						
Finfish	150	315	915	1,188	5,507	36.7
Shrimp	285	690	1,275	343	986	3.5
Mollusc				3,773	10,600	
Seaweed				17,224	21,464	

kg/ha = kilograms per hectare.
Source: Li 2003.

Annex 6: The Chinese Academy of Fishery Sciences organizational structure



Source: Yang 2003.

Annex 7: Institutes for fishery education in China

Table A7.1: Fishery universities, colleges and departments in China

Name	Administration	Location
Universities and colleges		
Shanghai Fisheries University	Ministry of Agriculture	Shanghai
Dalian Fisheries College	Ministry of Agriculture	Dalian
Xiamen Fisheries College	Ministry of Agriculture	Xiamen
Zhenjiang Fisheries College	Ministry of Agriculture	Zhejiang
Zhenjiang Fisheries College	Zhenjiang Province	Zhoushan
Fisheries College, Qingdao Marine University	Nation Education Committee	Qingdao
Wuxi Fisheries College, Nanjing Agriculture University	Ministry of Agriculture	Wuxi
Fisheries College, Huazhong Agriculture University	Ministry of Agriculture	Wuhan
Fishery Departments		
Southwest China Agriculture University	Ministry of Agriculture	Chongqing
Jilin Agriculture University	Jilin Province	Jiling
Jiangxi Agriculture University	Jiangxi Province	Nanchang
Tianjin Agriculture College	na	Tianjin
Anhui Agriculture College	Anhui Province	Heiphi
Guangxi Agriculture College	Guangxi Zhuang Autonomous Region	Nanning
Sichuan Animal Husbandry College	Sichuan Province	Younchang
Hunan Agriculture College	Hunan Province	Changsha
Suzhou Mulberry Technical School	Jiangsu Province	Suzhou
South Hunan Agriculture School	Henan Province	Xinyang

na = not available.
Note: Institution names and administrative authority may have changed with government reorganization.
Source: Li and Mathias 1994.

Table A7.2: Fishery technical schools in China

Name of institute	Location
Shandong Provincial Fisheries School	Yantai, Shandong Province
Jimei Fisheries School	Xiamen, Fujian Province
Beijing Fisheries School	Beijing
Tianjin Fisheries School	Tianjin
Shanghai Fisheries School	Shanghai
Hebei Provincial Fisheries School	Qinhuandao, Shandong Province
Sichuan Provincial Fisheries School	Heichung, Sichuan Province
Guangdong Provincial Fisheries School	Guangzhou
Guangxi Provincial Fisheries School	Nanning, Guangxi Zhuang Autonomous Region
Heilongjiang Provincial Fisheries School	Harbin, Heilongjiang Province
Lianyungang Fisheries School (Provincial)	Lianyungang, Jiangsu Province
Hubei Provincial Fisheries School	Wuhan, Hubei Province
Anhui Provincial Fisheries School	Hefei, Anhui Province
Dalian Fisheries School	Dalian, Liounin Province
Zhoushan Fisheries School of Zhejiang Province	Zhoushan, Zhejiang Province
Zhejiang Provincial Fisheries School	Hangzhou, Zhejiang Province

Note: Institution names and administrative authority may have changed with government reorganization.
Source: Adapted from Li and Mathias 1994.

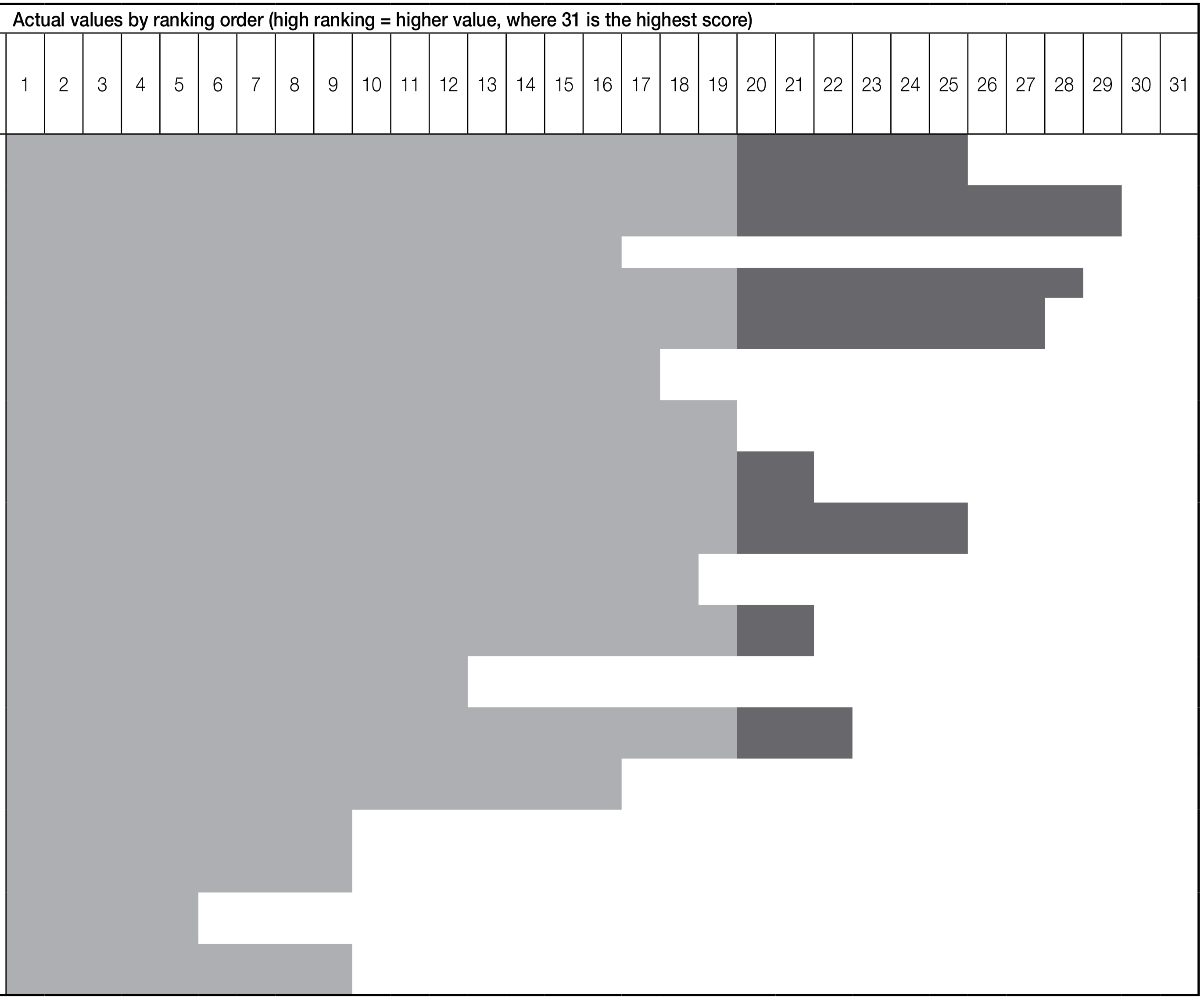
Annex 8: Production of animal protein in China, 1983-2006 (in 10,000 t)

Year	Pork	Beef	Mutton	Poultry	Egg	Milk	Fish
1983	1,316	32	55	na	332	na	546
1984	1,445	37	59	149	432	na	619
1985	1,655	47	59	160	535	na	705
1986	1,796	59	62	188	555	333	824
1987	1,835	79	72	219	590	379	955
1988	2,018	96	80	274	696	419	1,061
1989	2,123	107	96	282	720	436	1,152
1990	2,281	126	107	323	795	475	1,237
1991	2,452	154	118	395	922	524	1,351
1992	2,635	180	125	454	1,020	564	1,557
1993	2,854	234	137	274	1,180	564	1,823
1994	3,205	327	101	755	1,479	609	2,143
1995	3,648	415	202	935	1,677	673	2,517
1996	3,158	356	181	833	1,897	736	2,813
1997	**3,596**	441	213	979	1,897	681	**3,602**
1998	3,884	480	235	1,056	2,021	745	3,907
1999	3,891	505	251	1,116	2,135	807	4,122
2000	4,031	533	274	1,208	2,243	919	4,279
2001	4,184	549	293	1,210	2,337	1,123	4,374
2002	4,327	585	317	1,250	2,462	1,400	4,566
2003	4,519	631	357	1,312	2,607	1,849	4,705
2004	4,702	676	399	1,351	2,724	2,368	4,902
2005	5,011	712	436	na	2,880	2,865	5,108
2006	5,197	750	470	na	2,946	3,303	5,290

Note: 1997 in bold to highlight that fish production has exceeded the production of all other types of animal protein since that year.
Source: NBSC various years.

Annex 9: Henan's socioeconomic ranking in China

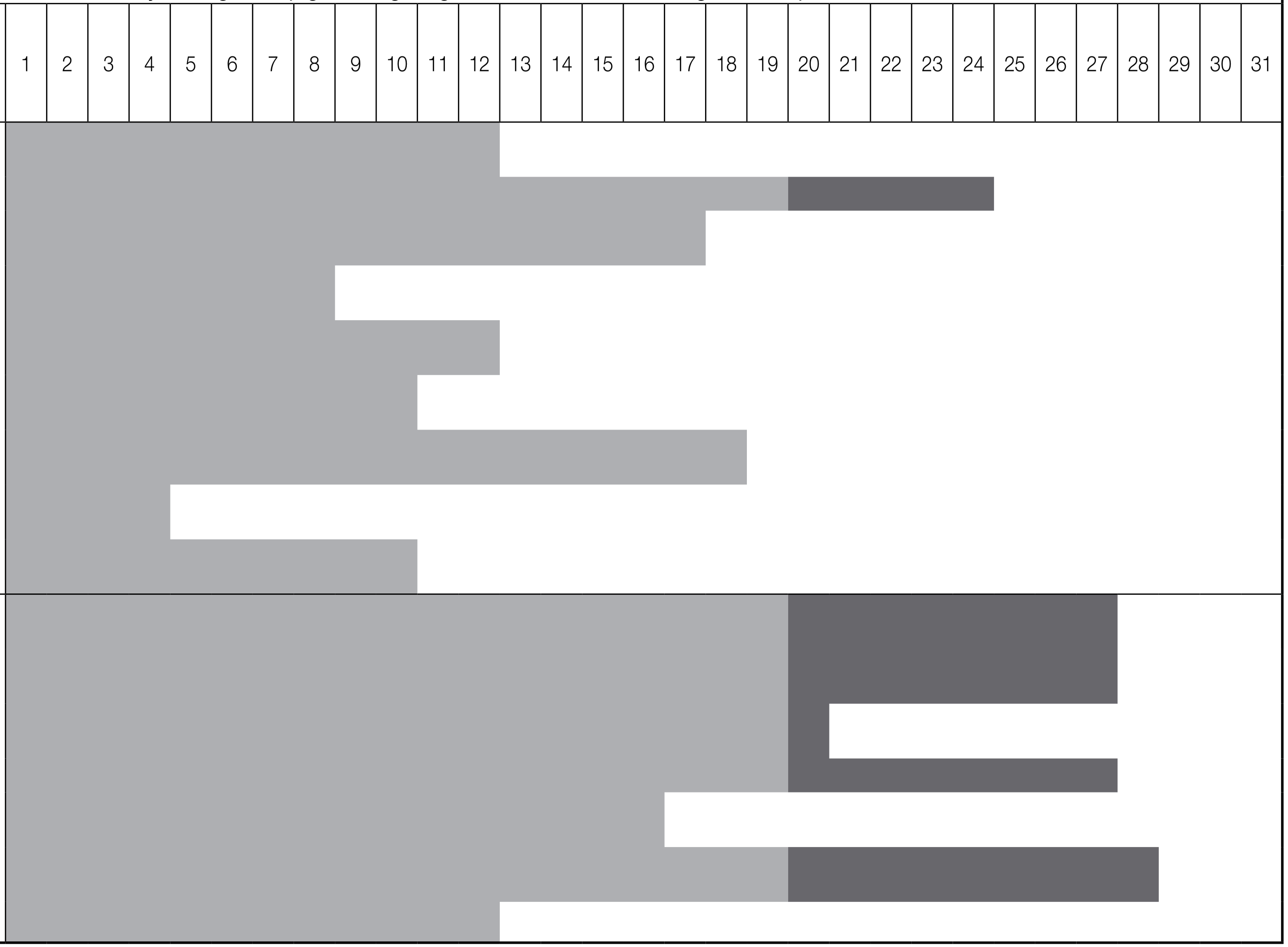
Key indicators	Variables	Value
Population, literacy and employment	Population density (people/km²)	569
	Rural population (% of total)	76.80
	Literacy rate (% aged 15+)	90.79
	Employment rate (% aged 15+)	75.25
	Employment in primary industry (%)	60.20
Fisheries	Share of fish culture area (% of country)	1.13
	Share of total fish production area (% of country)	3.58
	Pond fish culture area (% of total cultured area)	48.45
	Pond fish production (% of total cultured production)	81.89
	Pond fish production (% of country)	2.28
	Pond fish production area (% of country)	4.13
	Lake fish production area (% of country)	0.33
	Reservoir fish production area (% of country)	5.58
	River fish production area (% of country)	0.96
	Rice field fish production area (% of country)	0.02
	Average fish yield (kg/ha)	1,598
	Fish yield in pond environment (kg/ha)	2,701
	Per capita fish production (kg/year)	3.18



Annex 9: Henan's socioeconomic ranking in China (continued)

Actual values by ranking order (high ranking = higher value, where 31 is the highest score)

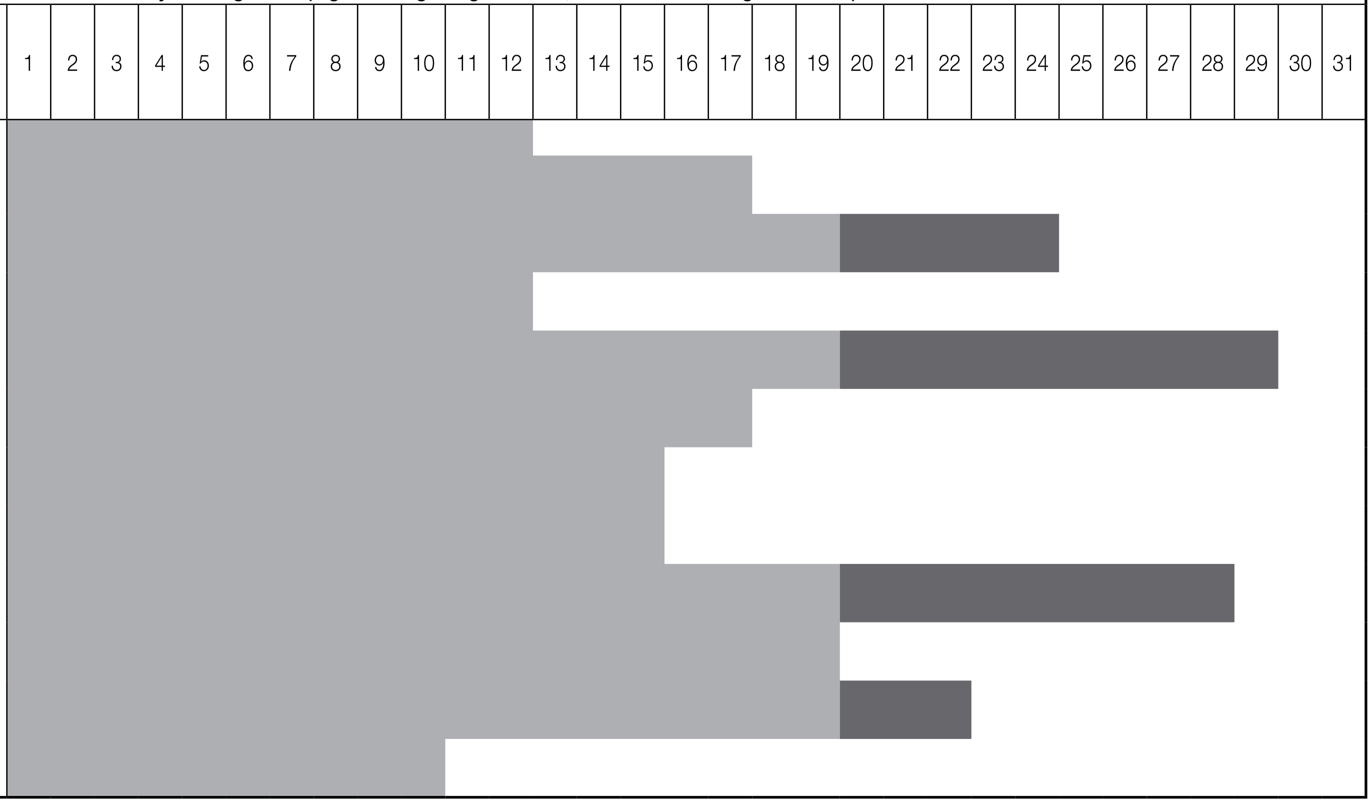
Key indicators	Variables	Value
GRP income and consumption	Per capita gross regional product (GRP) (yuan)	7,417
	Henan GRP (% of country)	5.20
	GRP from primary industry (% of total)	17.59
	Per capita income of urban people (yuan)	7,245
	Per capita income of rural people (yuan)	2,236
	Per capita food expenditure of rural people (yuan)	727
	Per capita consumption of food (kg/year)	364
	Per capita consumption of meat & poultry (kg/year)	7.71
	Per capita consumption of aqua product (kg/year)	1.35
Agriculture and productivity	Share of cultivated area (CA) (% of country)	6.24
	Share of area cultivated in Henan (%)	48.58
	Irrigation coverage of cultivated area (%)	59.09
	Fertilizer use (kg/ha)	576.91
	Electricity use (kilowatt/household/year)	536.20
	Cropping intensity (% of gross cropped area)	166.61
	Forest cover (% of total area)	12.52



Annex 9: Henan's socioeconomic ranking in China (continued)

Actual values by ranking order (high ranking = higher value, where 31 is the highest score)

Key indicators	Variables	Value
Agriculture and productivity(continued)	Wetland area (% of total area)	3.74
	Area cultivated with rice and wheat (% of CA)	66.04
	Area cultivated for total cereal production (% of CA)	87.87
	Area cultivated for rice production (% of CA)	6.42
	Area cultivated for wheat production (% of CA)	61.28
	Area cultivated for maize production (% of CA)	30.44
	Area cultivated for soya & oil production (% of CA)	16.15
	Area cultivated for vegetable production (% of CA)	11.29
	Agricultural labour (% of workforce)	50.93
	Number of big animals per 100 households	54.49
	Per capital meat production (kg/year)	63.51
	Per capital aquaculture production (kg/year)	4.10



ha = hectare, kg = kilogram, km^2 = square kilometre,
CA = cultivated area
Source: NBSC 2004.

Annex 10: Freshwater fish culture – area, production and environment in China by province, 2001

Region/ province	Total area and production		Pond environment			Lake environment		
	Area utilized ('000 ha)	Production (t)	Cultured area (ha)	Production (t)	Dominant culture practice	Cultured area (ha)	Production (t)	Dominant culture practice
National total	5,278	15,169,365	2,219,976	10,876,472		894,861	933,065	
Beijing	23	75,045	7,723	67,273	Intensive			
Tianjin	32	188,554	23,178	161,688	Intensive	3,567	18,469	Extensive
Hebei	85	256,860	29,798	179,438	Semi-int.	13,953	16,062	Extensive
Shanxi	17	25,826	3,446	20,458	Semi-int.	820	686	Extensive
Inner Mong.	126	45,354	7,981	23,464	Semi-int.	65,407	10,502	Extensive
Liaoning	130	330,001	33,918	259,251	Intensive	62	117	Extensive
Jilin	212	96,164	20,246	44,366	Semi-int.	74,639	19,143	Extensive
Heilongjiang	381	324,518	130,417	239,396	Semi-int.	121,776	30,259	Extensive
Shanghai	39	159,010	18,742	122,634	Intensive	9,215	6,214	Extensive
Jiangsu	562	1,882,357	280,247	1,232,962	Intensive	92,280	154,348	Extensive
Zhejiang	208	514,225	61,985	303,604	Intensive			
Anhui	549	1,281,106	227,932	807,010	Semi-int.	168,404	232,371	Extensive
Fujian	91	497,317	35,531	340,349	Intensive	726	2,539	Extensive
Jiangxi	337	1,038,693	104,866	601,443	Semi-int.	82,335	101,832	Extensive
Shandong	245	941,258	130,134	698,351	Semi-int.	11,305	49,242	Extensive
Henan	189	302,259	91,650	247,535	Semi-int.	2,917	3,096	Extensive
Hubei	584	1,948,444	284,645	1,560,068	Semi-int.	151,982	208,435	Extensive
Hunan	416	1,202,555	216,044	892,608	Semi-int.	58,467	66,551	Extensive
Guangdong	370	2,192,139	245,091	1,961,462	Intensive			
Guangxi	178	712,666	73,527	443,869	Intensive			
Hainan	45	134,674	14,823	99,255	Intensive	26	142	Extensive
Chongqing	57	187,514	29,625	101,980	Semi-int.			
Sichuan	158	475,008	85,455	228,759	Semi-int.	3,032	1,666	Extensive
Guizhou	26	54,418	4,471	12,722	Semi-int.	338	60	Extensive
Yunnan	82	144,936	28,728	101,464	Semi-int.	12,502	2,737	Extensive
Tibet	0.018	20	18	20	Semi-int.			
Shaanxi	29	57,635	9,538	46,545	Semi-int.	7,475	2,806	Extensive
Gansu	19	13,440	3,157	9,893	Semi-int.			
Qinghai	6	1,074	521	512	Semi-int.	4,500	275	Extensive
Ningxia	12	36,419	6,155	31,128	Semi-int.	4,282	4,874	Extensive
Xinjiang	70	49,876	10,384	36,966	Semi-int.	4,851	639	Extensive

ha = hectare, Mong. = Mongolia, t = tonne.
Source: NBSC 2002.

Annex 10: Freshwater fish area, production and environment in China by province, 2001 (continued)

Region/ province	Reservoir environment			River environment			Rice field environment		
	Cultured area (ha)	Production (t)	Dominant culture practice	Cultured area (ha)	Production (t)	Dominant culture practice	Cultured area (ha)	Production (t)	Dominant culture practice
National total	1,620,978	1,493,797		378,097	664,028		1,532,381	745,799	
Beijing	14,979	5,236	Extensive				74	3	Extensive
Tianjin	4,533	4,618	Extensive	641	2,657	Semi-int.	952	522	Extensive
Hebei	37,802	52,316	Extensive	2,317	4,983	Extensive			
Shanxi	12,790	4,346	Extensive	267	321	Extensive			
Inner Mong.	50,271	9,631	Extensive	2,039	488	Extensive	1,770	1,048	Extensive
Liaoning	82,710	31,355	Extensive	3,145	2,213	Extensive	42,238	26,629	Extensive
Jielin	117,468	28,692	Extensive				5,287	2,633	Extensive
Heilongjiang	102,161	24,762	Extensive	22,099	14,724	Extensive	94,714	12,654	Extensive
Shanghai				9,648	15,385	Extensive	5,107	5,139	Extensive
Jiangsu	24,453	21,519	Extensive	115,067	198,642	Extensive	196,527	178,401	Extensive
Zhejiang	86,129	46,532	Extensive	51,553	77,890	Extensive	68,162	54,775	Extensive
Anhui	68,966	57,036	Extensive	72,434	132,292	Extensive	28,794	21,275	Extensive
Fujian	44,907	69,105	Extensive	6,198	27,301	Semi-int.	27,600	18,049	Extensive
Jiangxi	135,847	213,110	Extensive	13,056	41,977	Extensive	128,951	74,559	Extensive
Shandong	94,267	160,335	Extensive	6,892	16,173	Extensive	911	470	Extensive
Henan	90,395	44,756	Extensive	3,632	4,873	Extensive	257	319	Extensive
Hubei	100,917	81,486	Extensive	14,180	28,994	Extensive	7,245	9,224	Extensive
Hunan	104,921	90,076	Extensive	13,149	21,749	Extensive	241,277	94,112	Extensive
Guangdong	113,793	167,833	Extensive	4,666	18,976	Semi-int.	34,214	21,381	Extensive
Guangxi	93,806	187,085	Extensive	7,011	24,095	Semi-int.	38,422	23,812	Extensive
Hainan	28,642	24,676	Extensive	1,091	3,082	Semi-int.			
Chongqing	23,935	35,934	Extensive	2,193	6,700	Semi-int.	113,171	40,902	Extensive
Sichuan	55,779	97,718	Extensive	12,858	15,929	Extensive	292,436	113,885	Extensive
Guizhou	18,800	5,009	Extensive	2,339	498	Extensive	127,132	21,932	Extensive
Yunnan	39,954	13,342	Extensive	418	894	Extensive	75,918	23,557	Extensive
Tibet									
Shaanxi	11,631	6,899	Extensive				474	109	Extensive
Gansu	15,462	1,057	Extensive	783	849	Extensive	822	359	Extensive
Qinghai	932	287	Extensive						
Ningxia	993	263	Extensive	5	4	Extensive			
Xinjiang	43,735	8,965	Extensive	10,416	2,439	Extensive			

ha = hectare, Mong. = Mongolia, t = tonne.
Source: NBSC 2002.

This document describes the historical background, practices, stakeholder profiles, production levels, economic and institutional environment, policy issues, and prospects for freshwater aquaculture in Henan Province, China. It is an output from a 3-year project that produced a decisionsupport toolkit with supporting databases and case studies to help researchers, planners and extension agents working on pond aquaculture. The purpose of the work, carried out in Cameroon and Malawi in Africa, and Bangladesh and China in Asia, was to provide tools and information to help practitioners identify places and conditions where freshwater pond aquaculture can benefit the poor, both as producers and as consumers of fish.

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